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ERRATA.

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TRANSACTIONS

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MICROSCOPICAL SOCIETY OF LONDON.

I.—*On the Structure of the Ligament connecting the Valves of Conchiferous Mollusks.* By E. J. Quekett, Esq., F.L.S.

(Read March 20, 1844.)

In examining the creatures belonging to this class of animals, it will be seen that Nature, for certain wise purposes, has so ordained their existence as to make them inhabitants of the water, and either to be fixed or have a limited power of locomotion, and has given them a protection in the shape of a shell, of dense, unyielding, organized materials, their structure being unfitted for an internal skeleton. This shell in great measure serves to prevent their soft bodies from becoming the prey of the voracious inhabitants of the deep, and also for defending them against the violence of the waves; to both of which causes of destruction they would be continually exposed if this means of defence were not given to their helpless frames.

In one division of the molluscous animals, the creature inhabits a mansion formed more or less in a spiral form. This is enlarged by new growths to the orifice as the necessities of the occupant demand, and is generally much larger than the animal within, which can retract itself to some distance in its interior in the time of danger from the pursuit of its enemies. It often occurs in certain species, in order to render this abode more secure, that the animal has attached to it an organ, formed generally of the same materials as the shell, called an operculum, which it has the power of drawing after it, and which effectually stops the mouth of the shell, and so beautifully is it fitted that it would defy the best workman to adapt a piece in the like manner.

With this barrier against its enemies, the creature can live securely, much more so than even we ourselves can, when we endeavour by the

same means to keep out intruders from our habitations. This operculum is capable of being adjusted so as to be suitable for its purposes.

If we can imagine that this moveable operculum could be jointed by a hinge or some such contrivance, to the edge of such an univalve shell, we should then see that this condition of structure would be analogous to a rudimentary valve, though it would be very unlike the other, still the transition from this arrangement to a shell composed of two more or less equal valves can be very easily reconciled.

The creatures inhabiting a shell composed of two more or less equal valves are denominated by zoologists "conchiferous mollusks," and the shell is termed a bivalve, in contradistinction to that inhabited by the other division of molluscous animals of which we have just spoken, which is denominated an univalve.

With this compound mansion it is requisite that there should be provided an apparatus by which these valves may be opened for the purposes of the creature within, and closed against the enemies without. It has been said that in those which occupy a single valve, the opening and closing of the orifice of the shell is effected by the protrusion and retraction of the creature's body bearing an operculum.

In the conchiferous division these methods do not obtain, and it is found that an apparatus exists which is compound in its nature, and not a portion of the animal as far as the great purposes of nutrition and reproduction are concerned, by which these actions are secured to these creatures.

One of these organs is *muscular*, its action depending on the will of the animal. The other is *mechanical*, that is, the action is effected by a power something analogous to elasticity, which is not destroyed even by death, but continues for a considerable period to possess this property.

In all conchiferous animals the closing of the shell is effected by one or two powerful muscles extending from one valve to the other at some convenient spots, depressions, or want of nacre or polish, generally indicating the attachment.

The contraction is exceedingly powerful, and the creature is capable of maintaining it for a lengthened period. The position of the muscle for effecting the closing of the shell, is placed generally not far from the centre, and maintains throughout the growth of the shell a relative distance between the hinge and the margin of either valve. On the inner side of the muscle are generally some ligamentous fibres,

which prevent, by their want of elasticity, a separation of the valves beyond a given distance, so as to take off from the muscular power anything in the shape of continued strain from elongation.

So far the observations have reference to vital endowments of the animals inhabiting bivalve shells, but it is chiefly to the character of the mechanical and physical condition of the hinge and ligament that this paper has particular reference.

If we examine the ordinary species of the *Conchifera*, we shall find that the majority present certain eminences and depressions which correspond in the two valves, and constitute what is denominated the hinge. This hinge varies materially in different genera: in the genus *Spondylus* the processes are so perfectly connected, that notwithstanding there is freedom of motion for a certain distance, the valves cannot be separated without a fracture of some of the processes; whilst in *Pinna* no processes exist, a ligamentous material forming the hinge.

Generally speaking, however, there are to be found certain eminences and depressions which are more or less developed, which form a kind of joint or hinge, whose presence prevents the valves only from slipping either forward or backward; the ligamentous structures keeping them in contact and completing a true joint.

It has been already stated that the opening of the shell is a mechanical action, effected by the ligament on the valves, on account of its being situated in such a position that its power may be effectively employed.

It would appear from Dr. Roget's 'Bridgewater Treatise,' vol. i. page 218, that this ligament had one universal position, and that its compression by the adductor muscle was the cause of the elastic power by which the valves are opened, it being there stated that "the closing of the valves produces in all cases a compression of the cartilage, the elasticity of which tends, therefore, to separate the valves from each other, that is, to open the shell."

If the most common bivalve shells be examined, such as the cockle, mussel and scallop, it will be seen at once that the former has the ligament external to the hinge, and the two latter have the ligament internal to the hinge, and in all these examples it is a power residing in the ligament that opens the valves.

Now it is very evident that a power before the fulcrum and a power behind the fulcrum, producing the same effect, must operate in a manner the converse of each other, that is, the ligament before the hinge, in order to open the valves, can only do so by expansion after

compression, whilst the ligament behind the hinge, can only effect the same end by contraction after being elongated after the closing of the shell by the adductor muscles.

This contrariety of action induced me to examine the structure of the ligament in those shells that have come within my reach, and I now propose to detail the results of my investigation.

In directing the attention to the different bivalve shells, it can readily be observed, without the assistance of the microscope, that in those shells in which the ligament is in front of the hinge, its structure appears horny and homogeneous, whilst, on the contrary, in those shells where the ligament is beyond the hinge, the structure of this organ appears to be composed of two distinct portions — an external, which is ligamentous and unyielding, and a central portion, in which appears to reside the power of contraction. This latter, in the dry state, appears friable and of a whitish colour, whilst the former possesses a black colour and a vitreous fracture.

Structure.— In examining the structure of the ligament placed before the hinge, it will be found that in certain species of *Spondylus* and *Pecten*, this organ manifests no perceptible structure, being to all appearance structureless, like "Indian rubber," whilst in other examples, as the pearl oyster, it is fibrous, and in the common mussel (*Mytilus edulis*), a very singular structure is discernible.

If a portion of the ligament taken from this animal be cut so thin as to be transparent, it will appear under a high magnifying power to be composed of a dense tissue, without any particular structure, in which are certain small channels, or *lacunæ*, filled with fluid; from this arrangement it would appear, that when the ligament is compressed by the adductor muscles approximating the valves, the presence of fluid in these *lacunæ* (by being incompressible) serves to render more tense the ligamentous structure, and thereby increase its elasticity.

When the attention is directed towards the structure of the ligament placed beyond or outside the hinge, it will be found to be composed, as already stated, of two substances possessing a different organization. This fact has been long known, for Dr. Roget, in his 'Bridgewater Treatise,' vol. i. page 217, says, "This ligament is composed of two kinds of texture, the one which is always external is strictly ligamentous, that is, perfectly inelastic; the other has more of the properties of cartilage, being highly elastic, and formed of a parallel series of condensed transverse fibres, directed from the hinge of one valve to the similar part of the other, and having generally a deep

black colour and a pearly lustre. The cartilage is always situated within the ligament, sometimes in immediate contact, and forming with it one and the same mass; at other times placed at a distance, in a triangular cavity amongst the teeth of the hinge."

It will be evident by a few examinations, that this statement, which is intended to convey a general idea of the structure of all kinds of hinge ligaments, is not reconcileable to all examples, but only to some particular instances.

If we take a portion of the ligament of the oyster, cockle, *Cardium costatum* or *Tridachna Hippopus*, we shall find the two structures above referred to, the external exhibiting no marks of structure, whilst the internal exhibits something remarkable.

On placing a fragment of the internal portion of the ligament of *Tridachna*, it will be seen to be composed of numerous fibres, each about the $\frac{1}{3000}$th part of an inch in diameter, running parallel to each other, and apparently crossed by others at right angles; but on submitting minute portions to very high magnifying powers, no trace appears to exist of these cross fibres, but each fibre appears to be composed of a cylinder, so formed as to present more or less transparent and greenish markings, at regular distances from each other; and the coinciding of these distances or spaces, as the fibres lie side by side, appears to give a transversely striated appearance. Nothing, however, like the disks in muscular fibre is evident, nor is there a spiral arrangement of atoms, but the striæ here visible are apparently produced by some such method as they are on the primary fasciculus of muscle, and there can be no doubt that this arrangement is contractile, otherwise the shell could never have its valves opened when the ligament is behind the hinge.

In examining one of these fibres more in detail, we find its length to be uncertain, probably extending from one valve to the other. In looking at it attentively, it appears to be of uniform diameter, and from its tenuity it decomposes the light in its transit, but the light is not decomposed uniformly, for there appear to be certain transparent spaces separated by green-coloured spots, the green colour apparently given by the decomposition of the light.

When we look to the office of this substance, which it appears evident is to open the valves, and which can only be done by this material contracting like muscular structure, for when the shell is closed it is overstretched, and contracts from elasticity. We have here a considerable analogy between the one and the other in office: a considerable analogy also exists between their structure, both being in

their ultimate condition fibrous, and having these fibres containing bodies, or appearing to contain them (at least in those belonging to the shell).

No sort of resemblance appears between the external view of the substance of the hinge and ordinary muscular structure, either in the recent or dried state. When in the latter, the contractile portion of the ligament becomes white and friable.

Like muscular force generally, the action of this material is placed under a very disadvantageous condition as far as power is concerned, having to act so near the fulcrum and yet to move portions so remote.

The power exerted by the ligament of the hinge must be immense in certain cases, for instance, the great shell of *Chama gigas* has a ligament containing this substance. No doubt this shell is opened by some power, for we hear wonderful tales of ropes being bitten off which have accidentally got between the valves; now it is evident that in order to bite, the valves of the shell must be opened a given distance by some method, and no one doubts that the ligament is contrived for this purpose; and as in the ligament no structure appears capable of contracting but that of which I have spoken, it is fair to presume that this is the source of power. The two valves of this gigantic conchiferous animal weigh frequently one hundred weight, consequently the power to be exerted in order to separate one valve from the other must be immense, as the ligament is not $\frac{1}{20}$ part the distance of the entire valve behind the hinge.

It appears extraordinary that an organ like this, so remote from the animal, should possess anything more than physical powers, or should possess any power analogous to muscle which can only be maintained by the blood or vital fluid of the creature, and presence of nerves, therefore, if this be endowed with contractile force, it offers a singular anomaly in the animal kingdom.

It has appeared to me, that the condition of this organ has been hitherto overlooked, and that its structure in the various species is deserving further investigation than that which I have bestowed upon it; still I have considered that there was sufficient interest in the observations that I have already made, to lead me to bring them before the notice of this Society this evening.

II. — *On some Phenomena connected with the Movement of the Cilia in the common Mussel,* (Mytilus edulis). By JOHN QUEKETT, Esq., Assistant Conservator of the Museum of the Royal College of Surgeons of England.

(Read April 17, 1845).

OF all the various objects presented to us by the aid of the microscope, none perhaps exceed in beauty and arrangement the phenomenon that has been termed ciliary movement, which is found to occur in more or less abundance throughout the whole of the various classes of animals both of the vertebrate and invertebrate series. No one can have witnessed this movement without having been struck with astonishment at its great beauty, and at the same time having been led to wonder by what species of mechanism such extraordinary effects could be produced.

As various as are these movements, so in like manner various have been the speculations on the probable use of such a series of organs as *cilia*. By some authors their movement has been attributed to a magnetic or electrical force, while one author in particular, viz., Raspail, has even gone so far as to deny the existence of *cilia*, and to attribute their appearance to an optical illusion.

The motion of *cilia* appears first to have been discovered in the *Infusoria*. Leuwenhoek may be said to have first noticed them; he mentions their occurrence in a species of *Volvox*, and recognizes their use. Our countryman Baker, in the year 1744, described them with tolerable accuracy in the wheel animalcule, and made a distinction between their rotatory and vibratile motions. Since then they have occupied the attention of Needham, Spallanzani, Otto Frederic Muller, and many other observers; but the great improvements which have been made in the microscope within the last few years, have led to the conviction that there is scarcely an animal in which the presence of *cilia* cannot be ascertained: and we are indebted to Mr. Lister, Dr. Grant, and to Dr. Sharpey in particular in this country, and to Purkinje and Valentin abroad, for nearly all that we know of this interesting subject.

In some animals, the *cilia* may be seen investing the whole outer surface of the body; in others they are confined to the edges; and

in others to some part of the internal organs only. In the animal in question, the common sea-mussel (*Mytilus edulis*), they principally occupy the gills or branchiæ, which are four in number, two on each side, and are easily known by their being brought into view when the shell is opened in the ordinary way, they being situated between the two lobes of the membrane lining the shell, which is termed the mantle. Each gill is composed of a series of bars placed parallel to each other, like the teeth of an ordinary comb, but with some connecting bars in the shape of small protuberances between them; besides this, each gill consists of two layers of such bars, which are united together at their edges, but have one layer free at the base, a few small bars placed rather obliquely serve to connect the two layers of each together. The edges where the union of the two layers takes place, are of a rounded figure, and on these the *cilia* occur in the greatest abundance, they being literally crowded with them on every part, but on the bars there are two rows on each side, one of the rows being much larger than the other, the large ones are more superficial than the others, and their motion is not so rapid as that of the small ones, in the former the beating or lashing motion is very perceptible, whilst in the latter it occurs so rapidly as to present the appearance of a continued series of undulations. It is to certain phenomena connected with the movement of the large *cilia* that I would direct the attention of the Society this evening.

If one of the rays be placed under the microscope with the large *cilia* uppermost, when the movement is nearly stopped, each *cilium* will be found (when viewed with a power of about 500 linear) to present, besides the usual curved motion in a vertical plane, another although slight yet important movement on itself, in a direction nearly at right angles to the preceding, which movement occupies just one quarter of a circle, and is precisely analogous to that of the quills in the wings in birds during their flight, or to what we are more familiar with, viz., the feathering of the oar in rowing. When we consider the fact that the fluid acted on by the movement of the *cilia* is always propelled in one direction, we are at a loss to imagine how such could be the case; if the *cilia* had only an upward and downward motion, why should not the current of water proceed first in one direction and then in the other? To get over this difficulty, and to account for the fact according to this view of the subject, the downward stroke, or that which impels the water, must be performed in a much less space of time and with a greater degree of force than that in the backward direction, but the problem can be easily solved by allowing that the

cilia are broader in one direction than in the other, and by giving to each of them a motion similar to that of the feathering of an oar, which has been before alluded to, and which I have found to be really the case.

To see this feathering movement in the most satisfactory manner, the *cilia* must have become nearly quiescent; and if that portion which is attached to the gill-ray, and which, for the sake of distinction, may be termed the root, be carefully examined, it will be found to make a circular movement whilst the filament itself is being bent upwards or downwards, the *cilia* also become alternately light and dark, in consequence of their being of a flattened figure, and the circular movement causes them to present at one time the broad surface, and at another the edge. The root of each *cilium* is of a globular figure, and Ehrenberg supposes that minute muscles are attached to this part, which give to it all its motions. In a preceding portion of the paper it was stated that there were two rows of *cilia* on each of the bars, the one much larger than the other, and differing in their motions, the one up and down in a vertical plane, the other quick and undulatory; and it would appear probable that the large *cilia*, by their motions, may cause the currents to and from the shell, whilst the smaller ones may be for the purpose of keeping in motion all the fluid which had entered between the *laminæ* of the gills.

In conclusion I would beg leave to state that at all times it requires some little care to get a satisfactory view of the motions above described; an hour nearly should elapse from the time the portion of gill is cut off until it be examined, and then the observer can hardly fail in making them out.

Having examined all the books I could think of which relate to the subject of ciliary movement, I have found that no notice has been taken of it, and deeming the subject of sufficient interest, I was induced to lay the same before the Society this evening.

III.—*Some observations on the Natural History of the Echinococcus.* By George Busk, Esq., F.M.S., &c.

(Read November 13, 1844).

By the *Echinococcus* I intend to signify the minute animalcule which is found in hydatid cysts in man and other animals.

The simple cysts containing these animalcules, are always situated in cavities in the interior of the animals infested by them. These cavities may be situated in any part of the cellular tissue of the body, but they are more usually found in the solid viscera, and most frequently in the liver and lungs, especially in the lower animals. I farther assume as proved, that all unadherent cysts, contained in such cavities as these, are of the same kind, and that although they differ in some respects in man and animals, they may be considered as of the same species in both, and that they all, without exception, contain *Echinococci*. And I farther express my conviction that these are the only species of non-adherent cyst contained in cavities, at present known. The proofs of these positions it would be perhaps out of place to adduce on the present occasion, as such an inquiry would not come within the scope of this Society. And I would only refer those who are desirous of satisfying themselves on these points, to a very complete and recent monograph on the subject of *Echinococci*, by M. Livois, to which I am indebted for the greater part of the short historical notice of the subject, which I will in a few words intrude on your attention before proceeding to those points more immediately interesting to the microscopic observer.

The history of the *Echinococcus* proves to us, that but little has been added to our knowledge of it since the first description by Pallas, in 1766, and who, had he been assisted by better optical appliances, would apparently have left little or nothing to be added, at least up to a certain point.

The animality of hydatids was first discovered by Hartmann, as far back as the year 1685, and Tyson in 1691, and the subject was resumed by Pallas in 1766 and the following years.

He first recognized the probability that hydatid cysts were always produced in connexion with an animalcule or worm similar to the *Cysticercus* (Zeder), and he says "that it is probable that the non-adherent hydatids sometimes observed in the human body, are either a

species of the *Tænia vesicularis* properly so called, or of those singular hydatids which I have remarked and described in the livers and lungs of calves and sheep, and which ought certainly to be attributed to a living creature, and which are evidently organized, at least as far as regards the interior pellicle, which is studded with granulations." And he remarks that "the vermiculi, furnished with a coronet of hooks and four stigmata, which are enclosed in the vesicles, are possibly a development of the globules which I had remarked (on their inner surface.)"

Pallas seems also to have been aware of the great similarity, if not of the identity, of the hydatid of man with that of animals, and of the different states in which they are found in each case.

The next writer who describes these animals is Goeze, in 1782, who very accurately describes the appearance of the animal and the situation and form of the hooks. He arranged them between the *Cysticercus* and the *Cœnurus*, and he points out the differences between them and the latter, with which Pallas had been inclined to confound them. He was of opinion also, that the vermiculi were connected to each other by a membrane or mucous pellicle, and that they had no adherence to the walls of the cyst: an error maintained, as we shall see, by later writers, and even by M. Livois himself.

In 1796, however, this adherence was observed by Blumenbach, in hydatids from the lungs of an ape.

In 1800 Zeder gives an account, though rather a confused one, of hydatids in the brain of a woman, and he makes it a species of *Cysticercus*. Up to this period it appears to have been the universal opinion that hydatid cysts always contained these animalcules, and the first writer of note who threw doubts on this subject was Laennec in 1804, who gives a most accurate description of the hydatid cyst, and the granulations which he observed adherent to its walls. He describes the granulations as composed of several individual vermiculi, which under the microscope he says are very nearly like the *Cysticercus*. He remarks the presence of the small, transparent, ovoid bodies in their interior. He was unable to determine their mode of adherence to the walls of the parent cyst, though he observed in one or two a sort of filament, which hung from the posterior part of the body. Laennec drew this description from hydatids taken from the liver of sheep. After reading this, it appears very extraordinary that he should have made the mistake he did when he came to examine the same creature in the human subject. He had already remarked the exact resemblance that the cysts in both cases bore to each other,

and he even saw what he calls colourless or oviform granulations, in those taken from the human subject, and which he supposed a mode of reproduction of the cyst — which he considered to be animated, and of which he constitued a distinct genus under the name of Acephalocyst. Rudolphi opposed this opinion of Laennec, and in 1808 again divided the class of vesicular worms into four genera: 1. *Cysticercus.* 2. *Anthocephalus.* 3. *Cœnurus.* 4. *Echinococcus,* under which he included those worms which were collected in large numbers in a common cyst, without, however, adhering to it in any way.

He subdivided the genus into three species, but has been unable to point out any distinctive characters between them.

After this, MM. Desmarest and H. Cloquet committed the extraordinary error of confounding the cyst itself with the animalcule, an error participated in also by Bremser, in 1817, although he mentions the contained animalcules; of which, however, he appears to have had a very obscure notion. He, however, recognized their animal nature in the globular corpuscles taken from cysts found below the clavicle of a woman.

Numerous other writers have more or less accurately treated on the same subject, but I will only farther advert to the researches of Kuhn, and to his opinions, which have so much modified the views of naturalists since his work appeared in 1832.

He adopted the erroneous opinion of Laennec, as to the reproduction of the Acephalocyst by buds detached from its internal surface, but to this he added another error, viz.: that in one kind this propagation took place by gemmules detached from the exterior of the cyst. The former of these species, or those propagating themselves by the detachment of cysts from the inner surface of the parent, he states to be peculiar to man, and the latter to animals. The former he termed *Acephalocystæ endogenæ,* and the latter *A. exogenæ.*

And it would be as well here, at once, to advert to the difference which really does exist between the cysts of the *Echinococcus* as found in man and in animals. A difference whose cause I am unable to assign.

In man, and in the ape tribe,* hydatid cysts are always found enclosed in large numbers, and of very various sizes, in the same cavity; and these hydatid cysts are always globular and even in their form: but

* Since this paper was read I have met with an instance of the multiple hydatid in the lungs of a pig.

in the *Ruminantia* the cyst of the hydatid is always solitary in its cavity, all the anfractuosities of which it accurately fills, and its shape is consequently very irregular. Another difference exists in the circumstance that, in man and the *Simiadæ*, the disease is usually confined to a single locality, while in the *Ruminantia*, hydatids are generally found disseminated in various viscera at the same time. Both circumstances, perhaps, indicating a greater difficulty to the dissemination of the seeds or eggs in the one case than in the other, probably in consequence of some difference in the constitution of the fibrinous layer which lines the containing cavity. In England, almost the first observation as to the connexion of hydatids and *Echinococci*, is that by Mr. Rose, in 1833 (Medical Gazette), who appears to think the connexion only occasional. They were afterwards treated upon more fully by Mr. Curling, in 1837.

In 1839, in the 'Cyclopedia of Anatomy and Physiology,' Mr. Owen repeats some of the errors of Laennec and others, and gives as figures of the human *Echinococcus* the incorrect representations of DelleChiage, but he adds from his own observation, what does not appear to have been seen by any other observer, viz., a description of the mode in which the *Echinococci* swim about in the fluid of the cyst by means of vibratile cilia. He also in another paper appears to consider the hooklets of the retracted head of the animalcule as resembling the teeth of the *polygastric Infusoria*, the stomachs of which, also, he considers the transparent vesicles seen in the body of the *Echinococcus*, to resemble, and the whole animalcule, he hints, should be classed rather with the *polygastric Infusoria* than with the *cystic Entozoa*. I will only remark upon this, that the cilia cannot be seen under any circumstances in the dead state of the animal, and that the true nature of the teeth or hooklets is too evident to allow of the above supposition being entertained.*

I will now briefly describe the *Echinococcus* and its containing cyst.

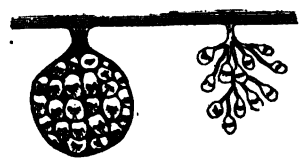
* In his lectures on the comparative anatomy of the *Invertebrata*, Mr. Owen repeats these observations, and then remarks on the absence of cilia in some dead *Echinococci* from a deer.

He also appears to consider them more as parasites of the Acephalocyst than as having any more intimate relation with it.

It is to be remarked that in those he himself observed, he did not notice any suctorial disks.

The cyst of the *Echinococcus* is contained, either singly or in numbers, in the interior of a cavity lined with an organized false membrane, to which it has no kind of adhesion whatever. It is found of all sizes, from that of a pin's head to many inches in diameter, and the thickness of the walls bears some, but no definite relation to the size of the bag, and in the larger cysts is not uniform. When recent, the cyst is transparent and colourless, but it soon becomes more or less opaque on immersion in water or spirit; in the former it swells if flaccid previously, and in the latter it shrinks by exosmosis.

The walls of the cyst are composed of numerous very delicate laminæ, of a diaphanous substance, which, in the opaque state, and under a high power, exhibit a very minutely granular aspect. All the laminæ are of extreme fineness, but the inner ones appear to be thinner and more readily detached than the more external ones, and the innermost of all is uneven and granular on the surface, and has adherent to it, in the natural and undisturbed state, the bunches or small masses of *Echinococci;* or rather these masses appear to be attached to the next layer to the innermost, which is prolonged over and envelops them. This may be better understood by inspection of the subjoined diagram.



Small opaque masses are seen here and there disseminated in the substance of the walls. The walls of the cyst are very elastic, and when a puncture is made in them the fluid is ejected with considerable force, and at the same time the internal membrane is usually detached, together with the adherent vermiculi, aud both are either expelled with the fluid or fall together to the bottom, forming a glutinous membraniform mass, in which it is sometimes difficult to find the *Echinococci.* All the cysts contain vermiculi, and the latter are probably not always more numerous in proportion to the size of the cyst.

The fluid contained in the cyst is limpid and colourless, and when

the cyst has not been disturbed and is quite recent, it exhibits under the microscope only the *Echinococci*, and occasionally some irregular granular masses.

The *Echinococcus*.—When a large hydatid cyst, for instance, in the liver of a sheep, very shortly after the death of the animal, is carefully opened, at first by a small puncture, so as to prevent the too sudden exit of the fluid and collapse of the cyst, its internal surface will be found covered with minute, opaque granulations resembling grains of sand. These bodies are not uniformly distributed all over the cyst, but are more thickly situated in some parts than in others. They are detached with the greatest facility and on the slightest motion of the cyst, and are rarely found adherent after a few days' delay. When detached, they subside rapidly in the fluid, and consequently they will then usually be found collected in the lowest part of the cyst and frequently entangled in fragments of its innermost thin membrane. When some of these granulations are placed between glass, under the microscope, each will be found to be composed of numerous individual *Echinococci*, more or less closely packed together, and enveloped almost entirely in a delicate membrane, Pl. 1. fig. 1. Upon farther pressure being employed, it will be seen, after the rupture of the enveloping membrane, that the *Echinococci* composing the granulations are all attached to a common central mass by short pedicles, which, as well as the central mass, appear to be composed of a substance more coarsely granular, by far, than that of which the laminæ of the cyst are formed (fig. 2). This granular matter is prolonged beyond the mass of *Echinococci* into a short pedicle, common to the whole, and by which the granulation is attached to the interior of the hydatid cyst as above described.

Fig. 2 also shows the mode of interunion of the *Echinococci*, and the fusion of their separate pedicels into a central mass of granular matter; and it is particularly to this point in the description of the *Echinococci* that I wish to call your attention, and to assure you of its reality, for it is one of those facts, which, though noticed by the earlier writers on the subject, has never been clearly described or figured, and any adhesion between the *Echinococci* and the cyst has been repeatedly denied by some of the first authorities on the subject, and partiularly by M. Livois, whose monograph shows the great pains and attention he has devoted to this subject, and whose observations and descriptions in other respects so minutely correspond with those I have been able to make.

The *Echinococcus* occurs in two forms, viz., with the head

and circlet of spines *retracted* or *exserted.* The former condition alone is that in which I have observed this animal in the fresh state. The other form I have myself only met with as the apparent consequence of incipient decomposition, and it has seemed to me to have arisen under these circumstances, from the imbibition of fluid swelling the body of the animal.

In the more usual state, or that in which the head is retracted within the body, the vermicule presents an ovoid form, flattened at the poles, and having a depression or notch more or less evident at each. (fig. 2.) The depression at the anterior cephalic or unattached extremity, is the orifice of a canal leading into the middle of the body, and by which the head with the circlet and hook is protruded. The double line proceeding from this orifice divides into two branches in the centre of the body, as is seen in the figures, and below this division is the circlet of spines on the retracted head. At the opposite posterior, caudal, or attached extremity of the body, the depression marks the place of insertion of the pedicle; it may be observed that this pedicle appears to perforate the outer tunic of the body and to be continuous with the granular matter in its interior.

I have not given any figure of the *Echinococcus* with the head protruded, as I believe they never occur in that state in the attached masses, and only when the animal has been spontaneously detached and perhaps farther developed, or as the effect of changes indicative of commencing decomposition. M. Livois' description of it, which is very accurate, states that "It is transparent throughout its whole extent, and about the middle of its length it exhibits almost always a sort of contraction, which separates into two portions. One posterior, more slender, which may be considered as its caudal vesicle; the other anterior, more swollen, upon which are placed the important organs of the little animal, viz., the hooks and suckers, and this may be regarded as the head of the worm."

This extremity is terminated by a hemispherical point, transparent and imperforate. The base of this elongated extremity or proboscis is surrounded with a double row of spines or hooks, which precisely resemble those of the *Tæniæ* and *Cysticerci*, and are falciform, with a process or apophysis on one side, probably for the attachment of a motor muscle. They are very sharply pointed, and some are larger than others, and the longer ones are those of the anterior row, and the hooks of each row are placed alternately. The arrangement of these spines is precisely the same in the *Echinococcus* of man and of animals." With reference to this point of the anatomy of the *Echinococ-*

cus, my own observations do not, as yet, allow me to express a positive opinion where so much difference exists among observers. But I am inclined to say that there is but one row of teeth in the crown. For the same reason, that I have not observed the animal in the developed state sufficiently, I can say nothing about the four suctorial disks described by all writers on the subject, and which, at all events, are not visible in the animal when the head is retracted. And M. Livois' supposition, that suckers like this must always be present in *Entozoa*, with hooks at the cephalic extremity, is obviously unsupported by Nature, for the whole class of *Echinorhynchi* have no suckers whatever, and yet find no difficulty apparently in infixing their heads into the mucous membrane of the intestines.

The body of the *Echinococcus* is covered with a thick, transparent membrane, the inner surface of which is rough, the outer smooth, and there appears to be a very narrow space between the inner surface of the tunic and the central granular matter. It is in this space, or between the outer tunic and the central granular matter, that the peculiar and curious transparent oviform bodies are placed, and only in this situation, and they are not, as most suppose, disseminated throughout the parenchyma of the animal.

This disposition of the transparent oviform bodies may be ascertained by inspection, having care to focus the glass slowly, and also by observing their annular arrangement on the lateral margins of the body, where the space in which they are situated is, as it were, seen in profile.

This position of them may also be proved by a simple experiment. If a drop or two of acetic acid be added to the *Echinococci* in a glass, the outer tunic will be seen immediately to swell or bulge out irregularly, and finally to burst and disappear, being, in fact, dissolved, and together with this, the transparent bodies escape, and also quickly disappear, leaving the body of the animal but little diminished in size or much altered in form, and without a trace of the oviform bodies, or spaces where they could have been. The same change also occurs as a consequence of decomposition, and in preparations that have been long kept or ill kept, this deprivation of the external tunic and subjacent oviform bodies, gives the animal an appearance altogether different from its true one, although some of the published figures appear to have been drawn from such altered specimens.

The same considerations and the same simple experiment prove that the body of the animal is composed internally of a tolerably solid material, and is not simply a vesicle containing fluid, as it is usually

described; and this central solid material appears to be very similar to that of which the pedicles are composed.

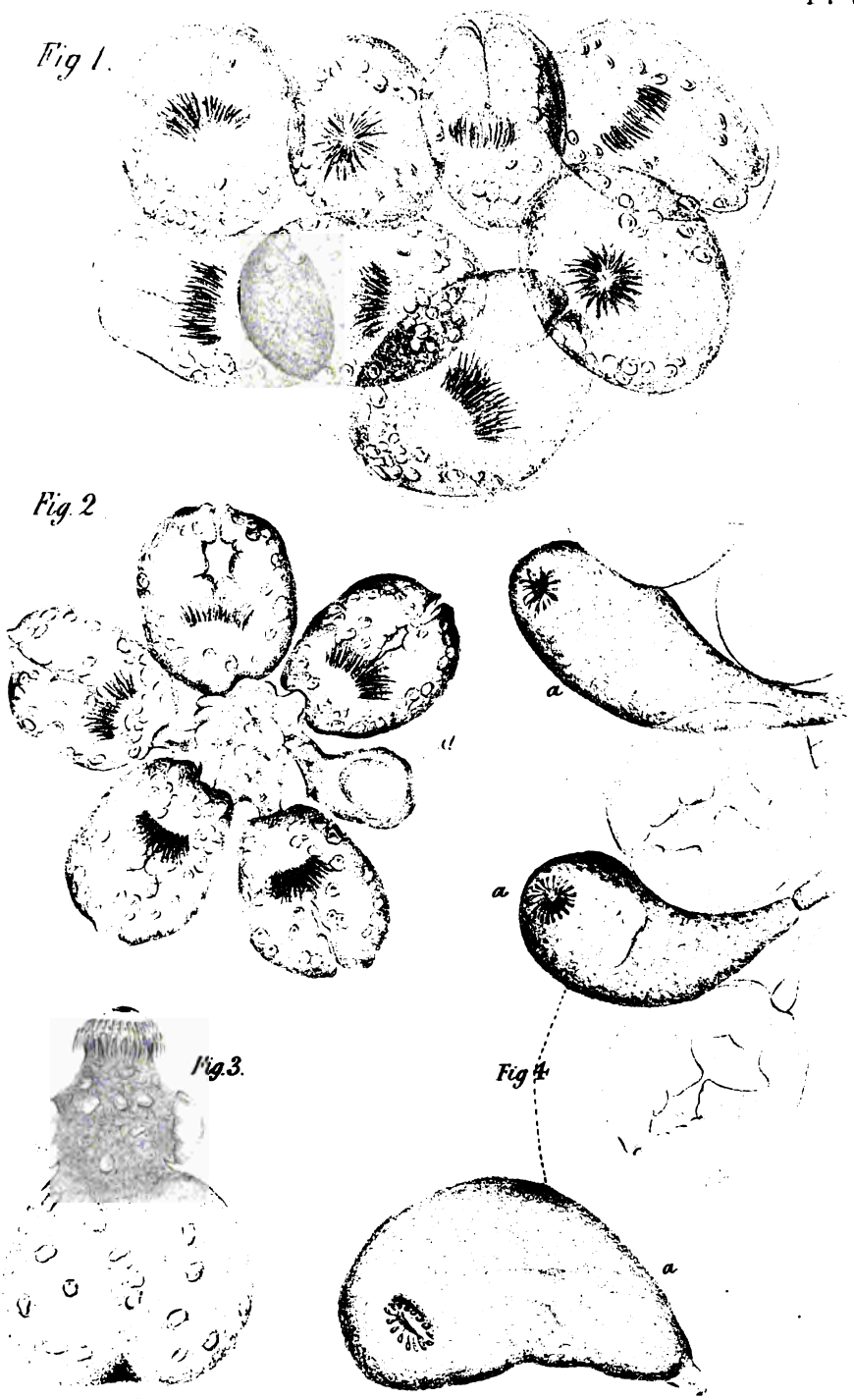
In specimens preserved in spirits, *Echinococci* of all imaginable forms and appearance may be met with,—differences owing to decomposition or mechanical injury; and in many cases no trace of them can be found except the hooklets or spines, which, like the fossil remains of animals, in Geology, remain as certain indications of their source, and not unfrequently afford the only proof we can obtain of the true nature of the hydatid.

With regard to the mode of propagation of these animals, I have nothing to advance further than to state, that I conceive the aggregate adherent masses to be a stage probably in their development, and that they proceed from a sort of gemmation, as described by Siebold (Physiologie de Burdach).

I will further remark in reference to this part of the subject, that in almost all the aggregations of *Echinococci*, are to be seen, besides the perfect *Echinococci*, one or more of a very different appearance, and of various shapes, rounded, clavate or oval, also attached by a pedicle to the central common mass, and usually rounded at the other (figs. 2, 4, *a*, *a*, *a*), composed of a granular material, denser apparently, and of a deeper colour, than that of which the bodies of the perfect animals are composed, and increasing in density or coarseness towards the free extremity. Of their true nature, if they are not partially developed *Echinococci*, I am unable to speak. I do not consider the transparent oviform bodies as ova. Some of them have a small central spot or nucleus, and of their true nature I am also ignorant.*

Much observation is yet required to determine the mode of the dissemination of the *Echinococci* in the bodies infested by them, as well as in the matter of their own reproduction. Upon both which points I had hoped to have been able to offer a few novel observations, but am prevented by the great scarcity this autumn of hydatids in the *Ruminantia*, probably in consequence of the long-continued

* Since this paper was read, in examining some *Echinococci* obtained from the liver of a man who died in Guy's Hospital, I observed a fact which may probably throw some light upon the nature of these oviform bodies or spaces, and in some measure justify Mr. Owen's comparison of them with the stomachs of the polygastric *Infusoria*. In this instance the hydatid cysts were contained in cavities of the liver, and bathed externally by a fluid deeply coloured with bile. The proper fluid, however, of the cysts themselves, was limpid and colourless as usual, but many of the transparent oviform bodies of the vermiculi were of a bright yellow colour, which I suppose to have been derived from the fluid external to the parent cyst.



G. Busk Delin. S. W. Leonard lith.

drought. I have been unable to obtain a single specimen for many months; and as any observations made upon these bodies must be made upon very recent specimens, owing to the rapidity with which their form is modified by *post mortem* changes, I have thought it better to defer them to a future opportunity.

EXPLANATION OF THE FIGURES, PLATE I.

Fig. 1. A granular body, or mass of *Echinococci*, contained in a delicate membranous envelope.

Fig. 2. Represents the mode in which the *Echinococci* are mutually attached and connected to a common central substance (*a*), vide Fig. 4, *a*.

*Fig. 3. An *Echinococcus* with the head, &c., protruded, the effect, probably, in this instance at least, of endosmosis after the death of the animal.

Fig. 4. *a*, *a*, *a*, and Fig. 2, *a*, Partially developed *Echinococci?* found intermixed with the more completely formed ones, in the granular bodies.

* At page 16 it is stated that no figure of the *Echinococcus* with the head protruded is given, nor was it my intention at first to exhibit one, but I have since thought it better to substitute the present figure of an individual in that condition, in place of the original "Fig. 3," which represented the creature in the opposite state. Its appearance, however, in that condition, is sufficiently shown in Fig. 2. With reference to this figure I would observe that the rounded projections on each side of the neck appear to be what are usually termed the suckers, but I conceive they can be otherwise explained, as I hope to show at a future occasion, should I be allowed to present some further observations on the subject.

IV. — *On Animals of the Chalk still found in a living state in the Stomachs of Oysters.* By the Rev. J. B. Reade.

(Read December 11, 1844).

"Si l'Auteur de la Nature est grand dans les grandes choses, il est très grand dans les petites."—*J. J. Rousseau.*

Many years before Geology was a science, it was observed by my relative, Dr. Paley, in his 'Natural Theology,' that "we never get amongst such original or totally different modes of existence as to indicate that we are come into the province of a different Creator, or under the direction of a different will." This remark had exclusive reference to living species of plants and animals in distant regions and under various climates, and it has been extended by Dr. Buckland to all the various extinct forms of many preceding systems of organization which we find entombed within the bowels of the earth. But while we thus recognize the constancy of Nature's law amidst the infinity of its modifications, it has been discovered, or, rather, asserted, that there is a break in the great geological chain of organized beings, and that a link is wanting to connect the cretaceous and antecedent series with the series of subsequent formations. In the primary and secondary formations, and again in the tertiary and recent, there is, in some cases, an absolute identity of organic structure in their respective animal or vegetable remains, which is supposed to be altogether wanting between the secondary and tertiary. "Below the tertiary formation," says Prof. Phillips, "are no recent species." From this point, therefore, the work of creation is dated anew, and upon this supposition is founded Mr. Lyell's arrangement of the subdivision of the tertiary system, his Eocene period, or dawn of our present animal and vegetable kingdoms, being coincident with the third geological era. About five years ago Dr. Mantell evidently felt some misgivings as to the accuracy of these views. He adopts Mr. Lyell's arrangement as one of great utility in the present state of our knowledge, but he adds, "it appears probable that it may require considerable modification, or, perhaps, be afterwards altogether abandoned with the progress of geological research, for it cannot be doubted that strata in which no recent species have been found may yield them to more accurate and extended observation." It is re-

markable that the converse of this supposition has actually obtained, and our modern seas have yielded living forms hitherto characteristic of the chalk formation, and regarded as antediluvial. The merit of this discovery rests with Prof. Ehrenberg. His elaborate researches were communicated to the Royal Academy of Berlin, and translations of the original papers, by Mr. Francis, have been published in this country in Taylor's 'Scientific Memoirs.'

I have now the pleasure of communicating to the Microscopical Society some observations of my own which confirm all the important conclusions arrived at by Ehrenberg, and are fortunately capable of easy verification. It will not be necessary to send for sea-mud from Norway, or for Peruvian or Mexican sea-water; half-a-dozen native oysters, or, in truth, I may say, the stomach of a single oyster, will often afford us ample proof of the uniformity and identity of organic life in distant ages of the earth, and leave us in no doubt that the dawn of the organic creation co-existent with ourselves, reaches further back into the history of the earth than has hitherto appeared.

The well known ciliary currents in the fringes of the oyster, induced me to examine the contents of the stomach, under the expectation of finding some minute forms of *Infusoria*; for it seemed but reasonable to infer that the absence of locomotive power and the consequent inability of seeking for food, might be compensated by so beautiful a contrivance for ensuring constant nourishment. My expectations were fulfilled and surpassed. In the stomach of every oyster I examined, and in the alimentary canal, I found myriads of living monads, the *Vibrio* also in great abundance and activity, and swarms of a conglomerate and ciliated living organism, which may be named *Volvox ostrearius*, somewhat resembling the *Volvox Globator*, but of so extremely delicate a structure, that it must be slightly charred to be rendered permanently visible.

This result, though highly interesting in itself, and marking so clearly the especial function of those instruments which fit the oyster for its peculiar place in the scale of created beings, is nevertheless of inferior importance, in a geological point of view, to some other results to which the presence of other *Infusoria* in the stomach of the oyster conduct us. These *Infusoria* I will briefly enumerate. They have siliceous loricæ, and belong to the family of the *Bacillariæ*, and some of these in their fossil state constitute the chief bulk of the chalk.

They are the following :—

Actinocyclus senarius	Gallionella sulcata
Ceratoneis Fasciola	Navicula Entomon
Coscinodiscus minor	Tripodiscus Argus
——— Patina	Xanthidium furcatum
——— radiatus	——— hirsutum
Dictyocha aculeata	Zygoceros Rhombus
——— Fibula	——— Surirella
——— Speculum	And two new species of this genus.

All the above, together with some well-known recent species of the same extensive family of the *Bacillariæ*, I have found in the stomachs of oysters. That they are not the detritus of chalk or chalk-marl, although identical as to species with the fossils of the chalk, is decided by the fact of my finding several of them alive; and even in the dead specimens there are the same distinct remains of ovaries and other organic details, which enabled Ehrenberg to pronounce with perfect accuracy that many similar dead forms had been recently in a living state. If further proof be required, it may be furnished by the process of charring, which immediately blackens the yellow membranous integument of several of the species.

We must not expect to find the same species of *Infusoria* in this new locality during every period of the year. Like creatures of a larger growth, oysters live on the food which is successively in season; and I find, in point of fact, that even a different shore is marked by a decided difference in the infusorial contents of the stomach. The "Scotch Natives" are characterized at the present time, by innumerable minute circular forms, resembling the *Coscinodiscus*. Our own oysters, on the contrary, are nearly destitute of these living rotatory disks, but they are much richer in more interesting species; and in addition to the siliceous-shelled *Infusoria* which are received into their stomachs, they also occasionally furnish examples of calcareous *Polythalamia* adhering to the inner surface of their shells. These latter microscopic cephalopods form part of the proper food of shrimps, and accordingly I find that very minute *Rotalia* pass into the stomachs of shrimps entire.

The comparison which Ehrenberg has conducted so successfully between the chalk and recent *Infusoria*, I have attempted to extend one step lower in the oolitic series, and to embrace in the investigation the *Infusoria* of the Kimmeridge clay. The large oyster beds which occur in this stratum in my own locality, the vale of Aylesbury, very naturally invite the search for the food of these ancient

mollusks. It will at once be admitted that they lived, like recent oysters, upon *Infusoria*, and that they possessed the same beautiful mechanism, though we cannot now detect it, for making a current of food set in in the direction of their stomachs. The very structure, then, of the oyster, independent of the result of any examination, determines the fact of the cotemporaneous existence of *Infusoria*, and their number may be approximately indicated by the countless bivalves themselves they were appointed to sustain. The supply would be equal to the demand, and, moreover, of so vast an extent, that the conclusion is unavoidable that the Kimmeridge clay, like the chalk, is formed very largely of organic bodies, and is not the mere comminuted detritus of more ancient and unorganized materials.

The result of examination confirms this view. I find in the Kimmeridge clay vast numbers of circular disks, already alluded to as existing in living oysters, and in addition to these I have met with decided examples of the *Coscinodiscus*, and portions of calcareous shells of *Polythalamia*. Under these circumstances we cannot fail to suspect an absolute identity between the genera and species of some of the minute and simple occupants of ancient and modern seas, though larger forms of more complicated mechanism have successively risen and disappeared. The oyster dissimilar from ours, may have fed upon our own *Volvox*, the *Volvox* on the *Monad*, and the *Monad*, — but here we must pause, lost among the wonders of the ever-living and life-giving Creator.

From the nature of the present inquiry, it may be extended, theoretically at least, beyond the Kimmeridge clay. On the evidence of analogy we may assume that the inhabitants of all bivalve shells, not only in the secondary, but also in the seas of the transition formation, were of similar habits to the acepalous mollusk which constructs the oyster-shell; that being destitute of jaws, tongue, or mouth, the action of a ciliary apparatus supplied them with food; and that their food consisted of an order of animals adapted, by their minuteness, to the delicate mechanism of the cilia, and designed, by their multiplication almost to infinity, to add mountain masses to the solid crust of the earth. We may hereafter be indebted to the microscope for the confirmation of these views.

I may embrace the present opportunity of further illustrating the use of the microscope in geological researches, by making a passing remark on the degree of heat to which the Kimmeridge clay has been subjected. Microscopic crystals of carbonate of lime, which abound in large portions of it, are either perfect cubes, or much nearer ap-

proximations to the cube than is consistent with their primitive form. That this alteration of the angle is due to the action of heat, and that the degree of heat is indicated by the angle ultimately assumed, is evident from the following remark by Prof. Brande:—"The temperature appears to affect the mutual inclinations of the planes of crystals. In the case of carbonate of lime, it amounts, according to Mitscherlich, to as much as 8.5′ in the interval of temperature between 32° and 112.° As the temperature augments, the smaller axis of the rhomboid dilates more than its other diagonals, so as to cause an approach to the cubical form."

It is my chief object, however, to show, with Ehrenberg, that animals of the chalk are still found in a living state; and having done this, it is needless, with Ehrenberg's paper in our hands, to point out, at any length, the importance of these researches. They bear directly upon mountain masses, and seem to make the vast chalk-range overstep its boundary, and connect itself rather with the tertiary and recent, than with the primary and transition formations. Beyond all doubt the bulk of the cretaceous series is composed of organisms still living, as I have now shown, in our own British seas, and, as Ehrenberg observes, still capable, under the concurrence of favourable circumstances, of giving rise to the greatest changes in the distribution of the solid crust of the earth. The material, and not the magnitude of *Infusoria* is the proper element in these calculations. We must shut our eyes to the minuteness of each individual atom of life, and look rather at the marvellous activity of its law of increase, and at its indestructible shield, which sets at defiance the two great reducers of organic structure, death and fire. A very few nut-shells would hold all we should leave of an elephant if reduced to its ultimate elements by fire, but no known intensity of heat would reduce the siliceous mass of *Infusoria*. Fusion, under certain conditions, would be the utmost result, and thence would originate other mountain masses, which, to say the least, would be very nearly allied to those which we term granitic. The question, then, is not unreasonable — was granite originally an infusorial earth?—and we accept Ehrenberg's hypothesis as the reply: "Since of the four as yet well established great geological periods of the earth's formation, the quaternary, tertiary and secondary formations contain recent organisms, it is as three to one more probable that the transition or primary formation is not differently circumstanced, but that, from the gradual longer decomposition and change of many of its organic relations, it is more difficult to examine and determine."

V. — *On certain peculiarities in the Structure of the Feathers of the Owl tribe.* By JOHN QUEKETT, Esq., Assistant Conservator of the Museum of the Royal College of Surgeons of England.

(Read January 15, 1845).

IT has been well observed by the eloquent Paley, that every feather is a mechanical wonder. If we look at the quill, we find properties not easily brought together—strength and lightness. If we cast our eye to the upper part of the stem, we see a material, made for the purpose, used in no other class of animals and in no other part of birds; tough, light, pliant, elastic. Feathers form a covering which cannot escape the most vulgar observation: the lightness, smoothness and warmth — their disposition all inclined backward — the down about the stem — the overlapping of their tips — their different configuration in different parts, not to mention the variety of their colours, constitute a vestment for the body, so beautiful and so appropriate to the life which the animal is to lead, as that, I think, we should have had no conception of anything equally perfect, if we had never seen it, or can now imagine anything more so. These were the expressions of this elegant author given to the world nearly half a century ago, since which time the structure and mode of development of feathers generally have been ably investigated by Frederic Cuvier and many other authors, and our knowledge of the subject greatly increased by their labours.

Before entering upon the consideration of the peculiar structure of the feathers of the owl tribe, it will be almost essential that I should explain briefly the various parts which enter into the composition of an ordinary (wing) feather, say a common goose-quill. Every feather may be said to consist primarily of three parts, the quill or barrel, the vane and the shaft. The quill, which is the part by which the feather is attached to the skin, is more or less transparent, and is shorter than the shaft. It is larger at the part where it is connected to the shaft than it is anywhere else, and tapers in most cases gradually to the point, where there is an opening communicating with the interior, which is termed the lower umbilicus, in contradistinction to another opening where the barrel joins the shaft, which is termed the upper umbilicus. In the interior of the barrel in the dry state is contained

a series of capsules fitted one upon the other and united together by a central pedicel. This is termed the pith by some authors, and is the remains of the pulp, which is seen as a highly vascular body in a young feather. The shaft is always more or less of a square form, tapering gradually from the point where it is connected to the barrel to its free extremity or apex, and is more or less curved. The outer side of the shaft is convex and horny, the inner is divided into two parts by a median groove, proceeding from the upper umbilicus; this also is horny, and the two inclose a white, elastic material, which is termed the pith. On minute examination, this is found to be composed of a cellular tissue very much resembling that of plants. From the two other sides of the shaft the vane arises; it is composed of a double set of horny filaments, termed barbs. These are given off at acute angles and are of a flattened figure, the flat sides being towards each other and the edges in the direction of the outer and inner side of the vane. From these edges another set of very minute filaments arises, which are termed barbules, and these barbules are often simple, but sometimes they have other little barbules arising from them, which, for the sake of distinction, I have named barbulettes. The barbules which arise from the upper margin of the barbs, or that nearest the free extremity of the quill, are curved towards the inner surface of the vane, whilst those which arise from the under margin of the same barb are curved upwards, so that the two hook nicely one into the other and keep the respective barbs in firm apposition.* We have now at least six elements entering into the composition of a single feather, viz., primarily, the quill, the shaft and the vane, and secondarily, the barbs, the barbules and the barbulettes.

This brief explanation of the parts entering into the formation of a perfect feather is quite essential to the understanding of certain peculiarities in the structure of the vane, which are to be found only in particular birds.

If the fingers be passed along the vane in a direction from the quill towards the apex, the individual barbs will be only forced more compactly together, but if the operation be performed in the opposite direction, the barbs, in some cases, will separate every here and there, but by far the greater number of them will be found so adherent one to the other, that some little difficulty will be experienced in getting them apart. If this be done before the light of a window or of a can-

* This locking together of the barbs was known to Hooke, and was figured by him nearly two centuries ago, in his 'Micrographia.'

dle, a series of little filaments will be noticed to cause this resistance. These filaments are the barbules, and it is by their locking one into the other that the great strength of the wing-feather is maintained. And of the many wonderful contrivances presented to us in Nature, none can exceed in beauty and simplicity of mechanism the structure in question.

In the wings of most of the *Hymenoptera* we have an analogous development of little hooks or barbules from the anterior superior margin of the second pair of wings. These, in the expanded state of the wings, are attached to a little fold on the lower margin of the first wing, and by this means serve to unite the two wings into one, so that greater strength is given to them, whereby the act of flight can be more rapidly accomplished. Another analogous use of hooks or barbules is presented to us in the lower part of the hairs of the common mole. The hairs of these animals, it may not be generally known, will lie quite smooth whether the skin be rubbed from the tail towards the head, or from the head towards the tail. Some of the hairs being much thicker and broader towards the free extremity than in any other part, the lower portion acts as a species of hinge on which the upper part can turn in any direction, whilst the lower gets its strength by holding on to its neighbours by its barbules, which are in some cases largely developed.

The feathers of birds which depend on flight as a means for their subsistence, are constructed nearly on the same plan; but there are others which are to be found on such birds as have no power of flying whatever. Amongst them may be mentioned the ostrich, cassowary, emeu and apteryx. If a feather be taken from the rudimentary wings of any one of these creatures, it will be found to differ greatly from the wing-feathers before alluded to. The barbs are very far apart, the barbules are largely developed, they are straight, and do not hook into those of the adjoining barbs, but hang quite loose and separate from one another, forming only a kind of down, so that however beautiful and ornamental such feathers may be to fit them for the flowing honours of a lady's head-dress, it is actually their want of development that makes them so highly prized.

But the principal modifications found in the wing-feathers of birds generally, are carried out to their fullest extent in the feathers of the owl tribe. If a wing or tail feather be taken from a bird of this kind and carefully examined, it will be found that besides the fastening together of the individual barbs by means of the barbules, there is an additional series of filaments developed from the sides of the barbules

themselves; these are destined not only to keep the adjacent barbs together, but to rise above the outer surface of the vane, and so form a kind of nap or down upon this surface. If we now compare one of these feathers with one from the wing of a goose or any diurnal bird of prey, the difference in structure between them will be very manifest; the one presents a surface perfectly level and smooth, whilst the other is covered with down, formed, as has been before stated, by the projection of the barbulettes above the outer surface. On the inner side of the feather the barbulettes do not rise above the level of the barbs, but on this inner surface the feathers of the owl tribe do not differ from those of other birds. It is on the outer surface only where the peculiarity above spoken of is to be found, the object of such structure evidently being for the purpose of rendering their flight perfectly noiseless.

Of all the many complicated problems presented to us in Nature's works, in none, perhaps, can we at once perceive more contrivance and design than in the construction of this part of the feather, and in none in which such problem will admit of so satisfactory a solution as the subject under consideration. Owls, it is generally known, go abroad at twilight, and their food consists principally of rats and mice, which, like the owls themselves, go abroad in the evening in search of food. Had owls the stiff and unyielding wing-feathers similar to those with which diurnal birds of prey are provided which depend upon the rapidity of their flight for the successful capture of their prey, the noise necessarily made in the act of flying would disturb the little animals in their repast, and they would be enabled to escape to their hiding places before they could be pounced upon by their unsuspected enemy.

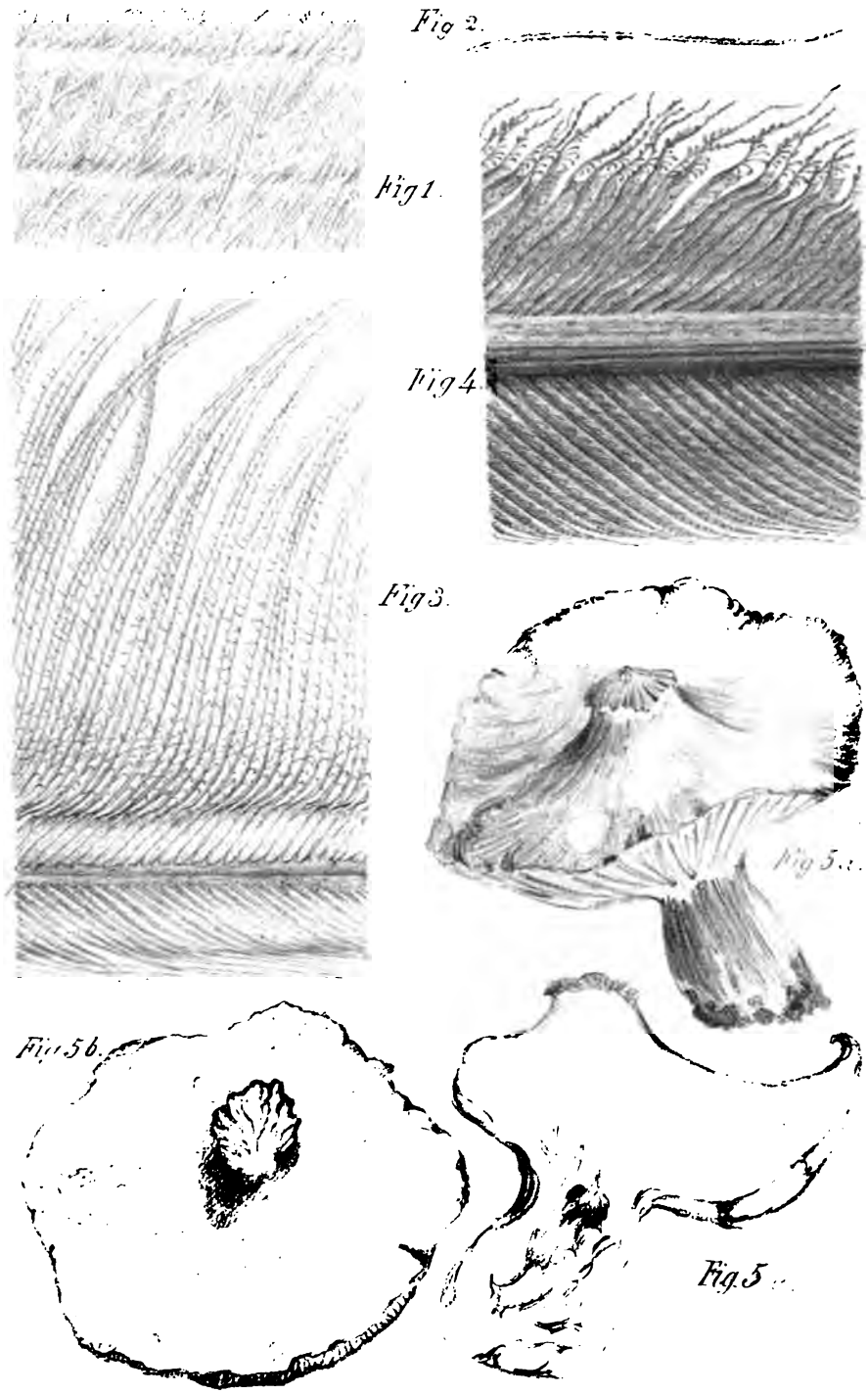
EXPLANATION OF PART OF PLATE II.

Fig. 1. A portion of the vane of a wing-feather of an owl (*Bubo maximus*), magnified 175 diameters. *a*, *a*, The barbulettes.

Fig. 2. A barb from the same vane of the natural size.

Fig. 3. A portion of one of the barbs magnified 175 diameters, shewing the barbules, *a*, and the barbulettes, *b*.

Fig. 4. A portion of a barb of a wing-feather of the crowned pigeon (*Columba coronata*), showing the barbules, *a*.



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VI. — *Remarks relating to the examination of Guano by the Microscope.* By Edwin J. Quekett, Esq., F.L.S., &c.

(Read January 15, 1845).

Having been induced by the constant adulteration of guano to seek some means by which the genuine may be distinguished from the adulterated, instead of the expensive and lengthened process of chemical analysis, I endeavoured to make use of the microscope for the purpose of effecting this object.

When viewed as an opaque object, guano appears to consist of particles of an earthy brown colour, mixed with glittering bodies of various sizes; some of the latter being distinct from each other, and appearing to be crystals and particles of sand; others, however, are collected more or less in bundles, and of needle-like character, and which undoubtedly are crystals only.

On examining various kinds of guano from different localities, it is to be seen that the proportion of the crystalline to the brown amorphous particles is subject to much variety, insomuch so, that it is quite possible to distinguish the Ichaboe guano from the Peruvian, by the former having so many more bundles as well as single crystals than the latter.

My friend, Mr. C. G. White, has also noticed the fact of the variation of the proportion of crystalline matter in different specimens of guano, and proposed the appearance to be a good guide for the collection of it, when a microscope in the hands of the collector would easily determine the valuable from the useless.

Unfortunately, however, it does not appear that the specimens which possess the greatest amount of crystalline matter are the best in the market, as the Peruvian has less than the African, and beside, the valuable matters of this compound are always flying away, and many specimens, though exhibiting abundance of crystalline matter, are nevertheless extremely inferior to others in which there is less, on account of the virtues residing in greatest quantity in the amorphous earthy looking portions.

Notwithstanding the microscope cannot determine accurately the value of the different samples for the agriculturist, it is quite capable of determining when the guano has been adulterated by foreign matters, on account of the different appearance it presents, as also in the

proportion of the crystalline to the earthy portions; and the peculiar nodulated character the latter exhibit could not be imitated by sand or such-like impurities.

Finding the examination of guano as an opaque object, with low powers, not altogether satisfactory, I had recourse to higher ones, and viewed it as a transparent object, moistened with water. This view quite unravelled the nature of many of the bodies, which, with a lower power it was quite impossible to understand.

In this state we can readily see that guano is composed of organized, crystalline and mineral matters.

The organized appear to be fragments of dried flesh, apparently that of birds or fish, as the characters of the muscular fibre justify the supposition.

Very minute fragments of shells, and abundance of spicules of sponge, of two or three kinds; and perhaps, what is most singular, very many specimens of animalcules belonging to the genera *Actinocyclus*, *Gallionella* and *Coscinodiscus*, especially in that from Ichaboe, though I have not yet detected many in the Peruvian.

When guano is digested in concentrated nitric acid, violent effervescence takes place, and most of its constituents are dissolved, and there only remain the siliceous, which exhibit clearly the animalcules and sponge-spicules.

Seeing guano composed of such various elements, it becomes a matter of speculation from whence several of them are derived, and in the first place the particles of muscular fibre, which appear to be those of birds and fishes. It is easily to be imagined, as the latter are so frequently devoured by the birds that inhabit these guano-islands, that portions of the flesh were passed through the digestive organs imperfectly digested, and were voided with the excrementitious matters. If it be the muscular fibre of birds, it is possible that its origin is from the death of the birds, whose flesh becomes after a while intermingled with the guano, many specimens of birds being dug up in a dried state, having suffered very little from decomposition.

The siliceous animalcules and sponge-spicules, it would seem, become present in the guano, from, firstly, being devoured by fishes, whilst adhering to sea-weeds or mingled with the sand, and secondly, the fishes being devoured by the birds, they are voided with the excrementitious matters of the latter. As the guano localities are always above the level of the sea, and the species of animalcules yet discovered are all of the character that inhabit the bottom of the ocean, the most probable reason for their occurrence is that above described.

The crystalline appear to be various salts, well known to constitute the most valuable portions of the manure. The mineral appear to be sand.

Frequently among Ichaboe-guano are to be found fragments of bones belonging to birds: these appear to have undergone a remarkable change, decomposition having in most cases destroyed the bony matter, while the form of the bone has been preserved by a crystalline substance, which forms a cast of the medullary canal. It would appear in many instances as if the bone had been converted into another material, but I have satisfied myself that in all cases the bony matter existed when the crystalline matter was deposited. If the crystalline matter was only a displacement of the true osseous substance, we ought to have the medullary canal as in the perfect bone, which is not the case, and which in the long bones of birds is extremely large. The form of the osseous corpuscles when the bone exists externally to the crystalline matter is precisely that of birds.

Mr. Warington has examined the crystallized matter, and finds it to be composed of sulphate of potash and ammonia.

To account for the presence of such a salt, it will be necessary to review the circumstances connected with the deposit of guano. All are tolerably well acquainted with the fact, that certain sea-fowl inhabit in myriads certain desolate islands in various parts of the world. The excrements discharged by such numbers congregated in one locality must naturally, if not quickly decomposed, add a covering more or less deep to the spot chosen as a place of resort by the birds. Let it be imagined that one of these birds should die, when in a short period its body would be entombed by its brethren, and decomposition would naturally go on to a certain extent, the aqueous portions that mingled with the solids would soon be evaporated in those dry climates, when the flesh would shrink and the bones lose the animal matters from their interior, and if things remained so, a perfect mummy, as is often found, would be the result. But in other instances it is to be supposed the dead carcass is buried in a damp situation, when speedily the whole mass of flesh would decompose, and the bones become infiltrated by water holding saline matters in solution, which it obtains by percolating through the upper stratum of guano. These saline matters entering the bones are disposed to crystallize in their medullary cavities, and which are ultimately filled by the compound previously mentioned.

We must, however, retrace a step further, to determine from whence comes the sulphate of potash (ammonia being readily engendered by

all decomposing animal matters, therefore its presence is readily accounted for). If we reflect that the guano is the excrement of birds which scarcely ever fly on land to obtain food, therefore their support is to be found in the plants or animals of the sea, and it is almost exclusively from the latter that they derive their food, consequently the elements of their excrement must be contained in the bodies of the fish. Then again, if fish have the elements of sulphate of potash in their systems, how do they obtain it? In the ocean in which they swim, potassium is found combined with chlorine, forming about $\frac{1}{1000}$ part of the whole. Sulphuric acid exists combined with magnesia and lime in somewhat larger proportions. Notwithstanding these exist in the water in such limited quantities, we are not to imagine that the fish derive any nutriment from the water any more than we do from the air, both elements serving essentially as the medium for supplying the oxygen for respiration. As fish undoubtedly either devour small animals or some of their species, and these, again, live on the vegetable materials found growing in the ocean, we ought to have the elements of this saline matter in such plants. According to the researches of Fordhammer in his paper read before the British Association in 1844, he has found potash in all sea-weeds; and remarks it as a singular fact, that notwithstanding there are forty times as much of the salts of soda in sea-water as of potash, the vegetable beings that grow in the ocean appropriate the latter to form a part of their tissue and refuse the former, which appears to be merely dissolved in the juices of the plant. Therefore we can trace the source of potash in the food of fishes, but we have yet one step further to retrace: from whence is the ocean supplied by this substance? Fordhammer has asserted that the small dewdrops that condense on the mountain, and become reinforced by others until they make the first streamlet, and also the rain that falls on the face of the earth and percolates the soil, both dissolve the saline matters in their course, till they reach the brook that conducts the waters to the tributary of some great river, when ultimately all the materials that are dissolved from the soil are mingled with the waters of the ocean.

Thus it would appear that there is a complete circle in many of the operations of Nature and of man, for since the discovery of the valuable properties of guano as a manure, by distributing it over the surface of the land, we are actually restoring the elements that had been removed by the rain, and which after a variety of changes in the system of vegetables and animals, are singularly restored to the earth from which they were first derived.

VII. — *On some abnormal forms of Fungi, with remarks on their Morphology.* By EDWIN LANKESTER, M.D., F.L.S., B.S.E. &c.

(Read March 19, 1845).

ALTHOUGH perhaps in the remarks I shall make in this paper I may not appear to have made such use of the microscope as would warrant me in bringing them before this Society, yet I feel myself justified in doing so, by the fact that the general subject of the Morphology of cryptogamic plants can only be prosecuted by the aid of the microscope.

Shortly after the frost which occurred in December, 1844, having occasion to visit Cheshunt, I found a monstrous specimen of the *Agaricus personatus*. It was already dried up and decaying from the effects of the frost. In all its parts, however, it exhibited a normal structure, with the exception of the pileus, in the centre of which, directly over the insertion of the stipes into the hymenium, a second and smaller hymenium was developed. The gills of this smaller hymenium were uppermost, and presented towards the light, the edges were covered with the pileus, which gradually united itself with the pileus of the lower hymenium. There was no appearance of any development of the stipes (Pl. ii. fig. 5, *a*). On making a section of the whole plant, no connexion between the lower and upper hymenium was discoverable, so that the latter was evidently an independent development (Pl. ii. fig. 5, *c*). The whole plant was in too dry a state to afford a favourable opportunity of ascertaining its structure by the microscope.

On placing the upper hymenium under the microscope, it presented a cellular structure like that observed in the higher forms of fungi. The same appearance was exhibited by portions from the undermost hymenium. The tissue was too much shrivelled to observe the sporophores, and no remains of spores could be found on either hymenium. Sufficient, however, could be seen to prove the identity of the two structures, and that whatever was the character of the lower and normal hymenium, the upper one was of the same nature. The tissue between the two hymenia was found to consist of oblong cellular tissue, mixed with which were the fibres of a lower form of fungus which had been developed during the destruction of its congener.

Several instances of abnormal forms of fungi are on record, but none that I am aware of precisely similar to the one in question. In the 'Icones Fungorum' of Schæffer, are several drawings of monstrous fungi, and one of an *Agaricus* exhibiting on its pileus two smaller fungi, but these two were perfect in every respect, and the pileus and hymenium were attached to a stipes which is fixed to the pileus of the original fungus. The Rev. M. J. Berkeley, in the 'English Flora,' gives an account of an *Agaricus campestris*, in which "a portion of the pileus was occupied by what at first appeared to be a parasitic *Sistotrema*, but, on closer inspection, proved to be a pulvinate excrescence of the mushroom itself, 1¾ of an inch broad, ¾ of an inch thick, occupied by spurious gills in the guise of subporiform jagged plates about 1 line deep, and producing sporules like those of the perfect gills beneath, but as it appeared to me rather more minute."—(p. 107).

Before concluding this paper, perhaps I may be allowed to make one or two remarks on the Morphology of the *Cryptogamia*. It is only by the observation of abnormal forms like the present, that we shall be enabled to point out what are the real relations of one form of fungus to another, and classify them according to their natural affinities. Morphology has done much for classification amongst phænogamous plants, but little or nothing amongst the cryptogamous. The 'Transactions of the Microscopical Society' contain, however, the record of a single fact of monstrosity amongst the mosses, which has afforded an interesting illustration of the application of the principles of Morphology in the higher departments of the animal kingdom; Professor E. Forbes, in his paper on the Morphology of the *Sertulariadæ*, having pointed out the analogy between the change of structure taking place in those animals and the mosses, from the similarity of form in their organs of nutrition and reproduction. Have we, then, in this fungus an analogous condition to that which has been found in the higher plants? If in the fungi we regard the pileus and stipes as the representatives of the leaf or nutritive organ in the higher plants, then the hymenium must be regarded as the analogue of the flower, or reproductive organs. We may then suppose that under the influence of cold or other external agent, an arrest of development in the vegetable tissue of the fungus would be attended with the development of reproductive tissue, as we know occurs amongst the higher forms of plants. It may be objected that we need some further proof that the pileus and stipes are really the analogues of the nutritive tissue. I think that this can be clearly made out by

passing along from the fungi to the lichens and from these to the *Hepaticæ* and the mosses and ferns, where every one will allow that the green parts are the nutritive tissue of the plant and the analogues of the leaves. There is one curious point with regard to the morphological structure of the fungi which I would here point out. It is, that the whole body of the fungus is the analogue of the flower in the higher plants, the thallus of all the *Cryptogamia* being in this family at its minimum of development; the only analogue of the thallus being the mycelium, which is seen in the early part of the development of all fungi, and disappears when the hymenium is developed. I may perhaps here be allowed to mention how beautifully this fact confirms the relation of polarity which Professor E. Forbes has pointed out, as existing in every part of the animal and vegetable kingdom. The *Fungi* and the *Algæ* must be regarded as parallel groups, and in fact, up to the present moment, there is no definition that will distinguish between many of their groups, so that a whole tribe, *Byssoideæ*, are referred sometimes to one, sometimes to the other, and sometimes distributed variously through each. The characteristics of the concentrate sphere are a tendency to concentration in the organs of reproduction, to the formation of an internal skeleton in the organs of support, and to a unity in the combination of its parts. Of these three characters the fungi are a remarkable exhibition, as seen in the Agarics, and generally in the higher forms of *Hymenomycetes*. On the other hand, the characters of the articulate sphere are a tendency to elongation, the formation of an external skeleton, and articulation, all of which characters are conspicuous in the *Confervæ*, the *Laminariæ*, and other forms of the family *Algæ*. The whole fungus may then be said to be the analogue of the flower, and just in the same way as the calyx and corolla stand in the relation of nutritive organs to the more especially reproductive stamens and pistil, so do the pileus and stipes stand in the relation of nutritive organs to the hymenium.

If such, then, be the real nature of the fungi, we should expect to find that this abnormal form would be permanently normal in some members of the family. I think such forms are indicated in the clavate forms of fungi, and in the Pezizas and other exosporous fungi generally. The Rev. M. J. Berkeley also informs me that he has received from Swan River, a new species of *Secotium*, (*S. melanosporum*) in which there are two isolated patches of hymenium on the stem, and in some species of this genus the hymenium sometimes extends entirely over the top of the stem.

With regard to the small fungi developed on the pileus drawn by

Schæffer, I would suggest that these are instances of increase from adhesion. During the development of the ovules of the higher plants, adhesion frequently takes place so as to produce a double seed, or a better illustration will be found in the instances of proliferous flowers, as seen in the common daisy called hen-and-chickens.

It is then probable that such instances of multiplication in fungi arise from the same cause, and that during their early development two or more spores are developed under the same volva, and the smaller fungi are nourished through the means of the larger one, just as the smaller flowers of the daisy grow on the larger one.

In submitting these remarks to the attention of the Microscopical Society, I do it with the hope of drawing attention to an interesting department of inquiry, and not at all with the feeling that I have given that attention to the subject which its interest and importance demand.

EXPLANATION OF PART OF PLATE II.

Fig. 5, *a*. View of stipes and pileus with abnormal hymenium of *Agaricus personatus*, from a drawing by Arthur Henfrey, Esq.

b. Pileus of the same fungus, with front view of an abnormal hymenium.

c. Vertical section of the same fungus.

VIII.—*On the Structure of the Flabella of some of the higher forms of Crustacea, with some remarks on their probable use in the function of respiration.* By JOHN QUEKETT, Esq., Assistant Conservator of the Museum of the Royal College of Surgeons of England.

(Read May 21, 1845).

THE respiratory organs of the *Crustacea* are with the common consent of authors called *branchiæ*, a term which applies equally to those which live on land as well as to those which inhabit the water.

In some members of the class, the branchial organs are very complicated, and consist of an apparatus designed especially for the decarbonization of the blood, in the shape of quadrangular pyramids, on whose sides are disposed parallel lamellæ, or tubes, on which the respiratory vessels are distributed. These organs are contained in an especial cavity, and further provided with an apparatus for the purpose of causing fresh currents of water to pass over the extended respiratory membranes. In other *Crustacea* no branchiæ are present, and the function of respiration is performed by certain appendages either to the locomotive or digestive system, which do not exist for the office exclusively, but are modified in such a particular manner as to perform the all-important function of respiration.

From the researches of Dr. Milne Edwards, it would appear that the embryo of the common cray-fish, *Astacus fluviatilis*, presents four principal periods in the development of its respiratory apparatus. 1stly.—That which precedes the appearance of branchiæ. 2ndly.—That during which the branchiæ are not distinguishable from the flabelliform appendages of the extremities, and which appear as mere processes of other organs destined either for locomotion or mastication. 3rdly.—The transformation of these organs into others of a more complex nature, but still external. And lastly, that during which the branchiæ sink inwards and become lodged in a cavity especially adapted for their reception, and provided with a particular apparatus destined to renew the water necessary to the maintenance of respiration.

The first of these conditions is presented to us in some of the inferior *Crustacea* which have no special apparatus for respiration; the

common *Entomostraca*, such as the *Cyclops*, *Daphnia*, *Cypris*, &c., which are so abundant in pools of stagnant water, may be cited as examples of this class.

In the second stage we find no proper branchiæ, but we have certain appendages to the digestive or locomotive systems on which are developed flattened membranous vesicles, highly vascular, which answer the purpose of branchiæ, and we have examples in the genus *Gammarus*, *Talitra*, &c., of this form of respiratory apparatus.

In the third stage we have the best examples in the *Squilla*, (Plate iii. fig. 1). Proper branchiæ are developed, but they are not contained in any cavity, but are attached to the basilar joints of the first five pairs of abdominal extremities, and each consists of a long cylindrical tube, from one of the sides of which proceeds a series of small tubes, disposed parallel to each other, and not unaptly likened by Milne Edwards to the pipes of an organ; these support, in their turn, a series of long, cylindrical, and very numerous tubes, (Pl. iii, figs. 2, 3). It may further be remarked that these branchiæ are continually exposed to the action of the surrounding water.

Lastly, the highest state of development of the branchial apparatus is found in the common decapod *Crustacea*, such as our ordinary crabs, (Plate iii, fig. 4), and lobsters, (Plate iv. fig. 1.) Not only have we in them a special apparatus for performing the function of respiration, but we have it lodged in an especial cavity, and certain accessary organs developed in the form of flabella, or sweepers, by means of which it has been supposed that currents of water, necessary for the decarbonization of the blood, are made to pass and repass over the whole of the branchial apparatus, (Plate iii., figs. 4, 4*a*, 4*b*).

In the lobster, the branchial cavity is open the whole way along its inferior edge, but in the crabs the afferent and efferent orifices are more circumscribed.

In the crab, the branchiæ themselves are of the shape of a quadrangular pyramid (Plate iii. fig. 7), the base being attached to the lower part of the chamber, or to a membrane which extends from its inferior edge to the basilar articulation of the corresponding limb. Each branchia consists of a septum, on each side of which are developed numerous lamellæ or plates; these lamellæ are arranged at right angles to the septum, and are of a quadrangular figure. On the upper side is developed a small hook or spine, to which attention will be again presently directed, (Plate iii. figs. 8, 3*a*, 10*a*). Upon the flattened surfaces of these plates the pulmonary capillaries are distributed, and the blood is returned after its purification to the heart by

the pulmonary vein, which is situated on the inner edge of the branchiæ, whilst the artery is situated on the outer edge. In the lobsters the branchiæ are constructed upon a different plan: they are somewhat like those of the crabs in their outward configuration, but instead of being composed of lamellæ, they consist of a number of cylindrical cæcal tubes, attached by their base to the septum. They stand erect, and are packed closely together side by side, like the bristles of a brush, (Plate iv. figs. 1, 2, 3, 5, 6).

In the crabs there are nine pyramidal branchiæ on each side, two of which may be said to be rudimentary, but in the lobsters there are as many as twenty-two. The flabella, or sweeping organs, are three in number, one on the upper row of the branchiæ, one on the lower row, and a third between the two rows, the latter is the shorter, (Plate iii. fig. 6, whilst one of the others is represented by fig. 5). They are of a flattened figure, and the hairs with which they are supplied are attached to the sides principally, and also on the broad surface opposed to the branchiæ, none being found on any other part, (Plate iii. fig. 11). These hairs, as will presently be noticed, are of a peculiar kind, differing in many respects from the hairs found in other parts of the body of the animal.

In speaking of the flabella in a preceding paragraph, it was stated that their probable use was that of causing currents of water to play constantly over the branchiæ, and this appears to have been the view entertained of their use by most authors who have devoted their attention to the subject, and amongst the most distinguished may be mentioned Cuvier, as advocating this opinion. In the 'Cyclopædia of Anatomy and Physiology,' article *Crustacea*, written by Milne Edwards, the following passage occurs:—" In the greater number of the *Decapoda* the flabelliform appendages of the maxillary or of the ambulatory extremities penetrate into the respiratory cavity, and by their motions as it were sweep or stroke the surface of the branchiæ. Some anatomists have even imagined, that it was by their action that the water necessary to respiration was renewed in the interior of the branchial cavities; but this is a mistake; these appendages have little or no influence upon the current which is continually traversing the respiratory antrum, and which is produced by the motions of the great valvular lamina, already described as belonging to the second pair of the maxillipedes, and situated in the efferent respiratory canal.

" The very secondary part which the flabelliform appendages of the thoracic extremities play in the interior of the respiratory cavities, is of itself a sure indication of the indeterminateness of their numbers

and relations to the branchial pyramids. Thus whilst in the lobster and the nearly allied genera, these appendages, to the number of five on either side, belong to the four first pairs of ambulatory extremities and to the third of the maxillary pairs, and run from below upwards between the branchial fasciculi, we only find three pairs in the *Brachyura*, belonging exclusively to the maxillary extremities, and penetrating into the branchial cavities horizontally, two on the outer surface of the *branchiæ* and one between the inner surface of these organs and the flancs."

I entirely coincide with Milne Edwards, that the use of the flabella is not merely to ensure the formation of currents in the water, for if we examine their situation in the common crab, we find that their movements are not in the direction of the inlet or outlet of the branchial cavity, but at right angles to it: they evidently answer another purpose; and now let us see what evidence the microscope will unfold of their probable function.

Having had occasion some time since to examine the hairs found on different parts of the more common *Crustacea*, I at length came to those situated on the flabella, and I observed that these hairs were remarkable for having a number of large hooks developed on one side only. The hairs themselves were not straight, but curved, or scimitar-shaped, and the hooks generally occurred on the convex side. In some specimens there were two rows of hooks, as seen in Plate ii. figs. 12—19. A transverse section of No. 19 is seen at fig. 20: this specimen was taken from the common crab, *Cancer Pagurus*; the hair of the flabella of the small edible crab, *Cancer Mœnas*, is represented by fig. 15; the other figures represent the hairs from the flabella of small species of crabs from different parts of the globe, but all exhibiting peculiar modifications of one and the same plan. Many of these hairs have still smaller hair-like projections on them, besides the hooks, and in most cases these little hairs are inclined towards the point of the large hair, and give to it an appearance of a serrated edge, fig. 14. By way of contrasting these hairs with those found on other parts of the same animal, I have represented the ordinary hair of a crustacean of the highest class at fig. 21.

Finding the appearance of hooks to be constant in all the species examined, I at once began to speculate on their probable use, and in the course of investigation my attention was directed to the structure of the *branchiæ*, and on a careful examination I found that on each branchial lamella there was a spine developed, which was very evident even to the unassisted eye, and as there are two series of lamellæ,

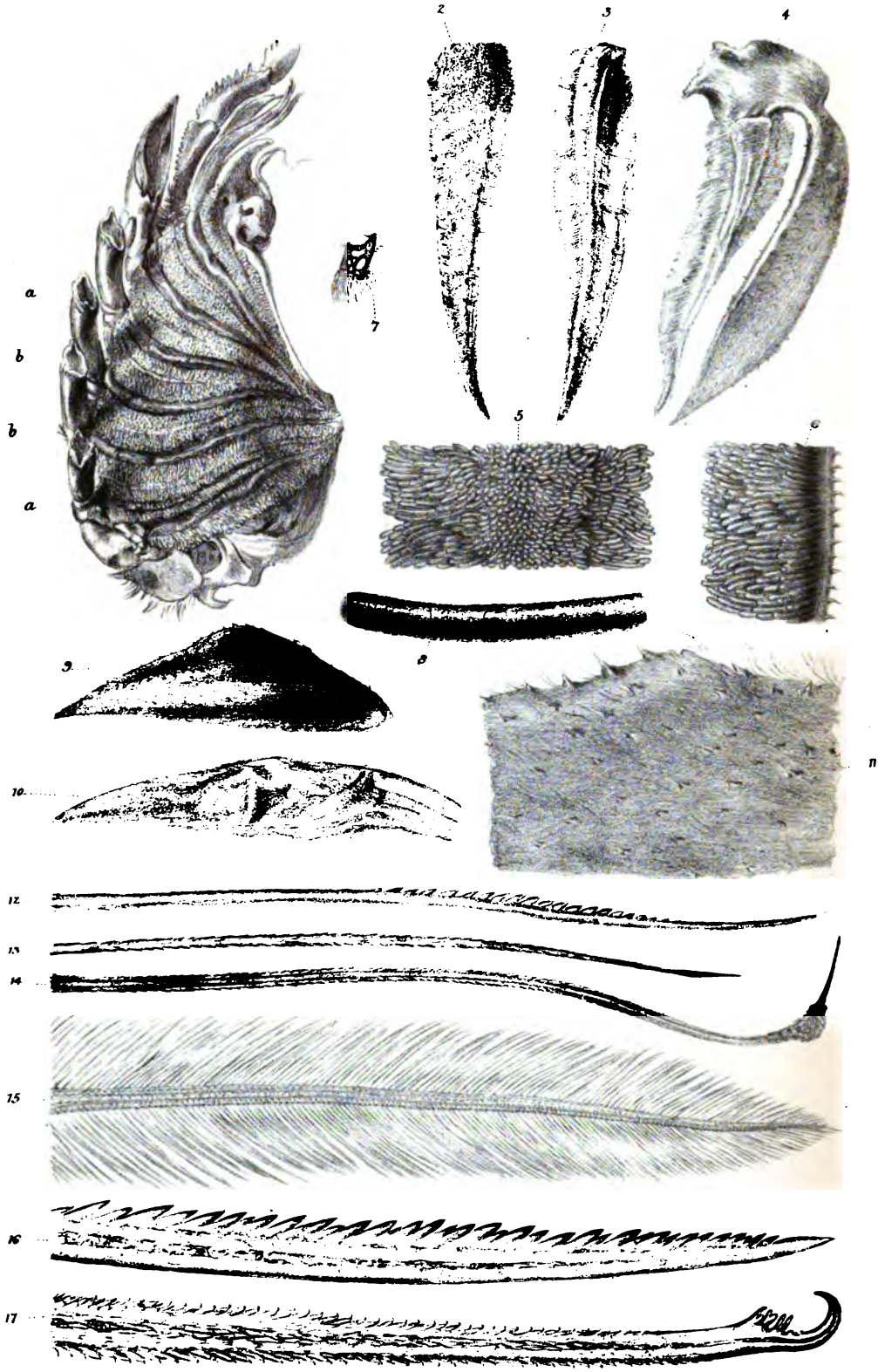
one on either side of the septum, there are two rows of spines on each branchia, (Plate iii. figs. 8—10, *a*, *a*). In some of the small crabs, spines are developed on the sides of the lamellæ as well as on their broad surfaces. The spines are of much firmer consistence than any other part of the lamellæ, and when touched with a pointed instrument the lamellæ can be moved backwards and forwards, and in passing the instrument from one end of the branchia to the other, a motion is produced like to that when a finger is passed along the tops of the teeth of a comb, the branchial lamellæ are rapidly separated one from the other; and this led to the conclusion that by the motions of the flabella the spines on the branchiæ may in some way become entangled with those on the flabella, and the branchial laminæ then would be separated, and the water contained in the branchial chamber would by this means be brought into better contact with the pulmonary capillaries distributed on the lamellæ.

When we reflect on this subject, some such contrivance as I have described must be necessary, and the very structure of the branchiæ themselves would warrant such a conclusion. The branchiæ, consisting as they do, of many hundreds of little plates closely packed together, would have no chance of having the blood circulating on their sides brought into contact with the water, unless there were some means of separating them one from the other. The *Squilla* and some of the other lower forms of *Crustacea* do not require such an apparatus, for every part of their rudimental branchial apparatus is constantly bathed in fluid, and being in continual movement, every part, however minute, must be in contact with water, they therefore require no sweeping organs; but the case is altered when we come to those higher *Crustacea* where the branchiæ are contained in a cavity, and through which cavity, even in the progression of the animal, no water would flow unless the valvular laminæ belonging to the second pair of legs were in constant movement.

In the lobster tribe it has been stated that we have a differently formed branchial apparatus to what occurs in the crabs, consisting of a number of cylindrical tubes attached by one extremity to a central stalk, (Plate iv. figs. 2, 3, 4, 5, 6). The free ends of these tubes are rounded, and within them the blood-vessels run. Fig. 8 represents one of the tubes highly magnified. If the flabella in these animals were constructed in the same way as those of the crabs, the presence of a spine would be required on each tube, but such is not the case, the flabella are arranged on a different plan to overcome this difficulty; instead of being thin and provided with hairs only on the sides,

the flabella are of a flattened figure (Pl. iv. figs. 9, 10), much broader than the branchiæ, and their edges, as well as both of their flattened surfaces, are covered with spines and with spiny hairs. The flabella are so placed between the branchiæ, that their broad surfaces are in immediate contact with the broad surfaces of two branchiæ, and as they are in constant movement, the effect produced must be like that of one brush being rubbed upon another, whereby all the tubes in succession are brought in contact with the surrounding fluid. Some of the hairs from these flabella are represented in Plate iv. figs. 12, 13, 14, 16, and the one represented by fig. 17, which is from the large cray-fish, is peculiarly adapted to the required office. Several other species of *Crustacea* have been examined, but all with the same result, nothing materially different having been found about their branchiæ to warrant a special description.

If the view that has been taken of the use of the flabella be the correct one, and indeed, all that can be seen would warrant such a conclusion, we have before us another instance of the great value of the microscope in anatomical researches, and an unquestionable proof that the aid of an assisted sense is often requisite to unravel some of the apparent mysteries of Nature, which mysteries show the more strikingly contrivance and design, the more deeply and carefully they are investigated.



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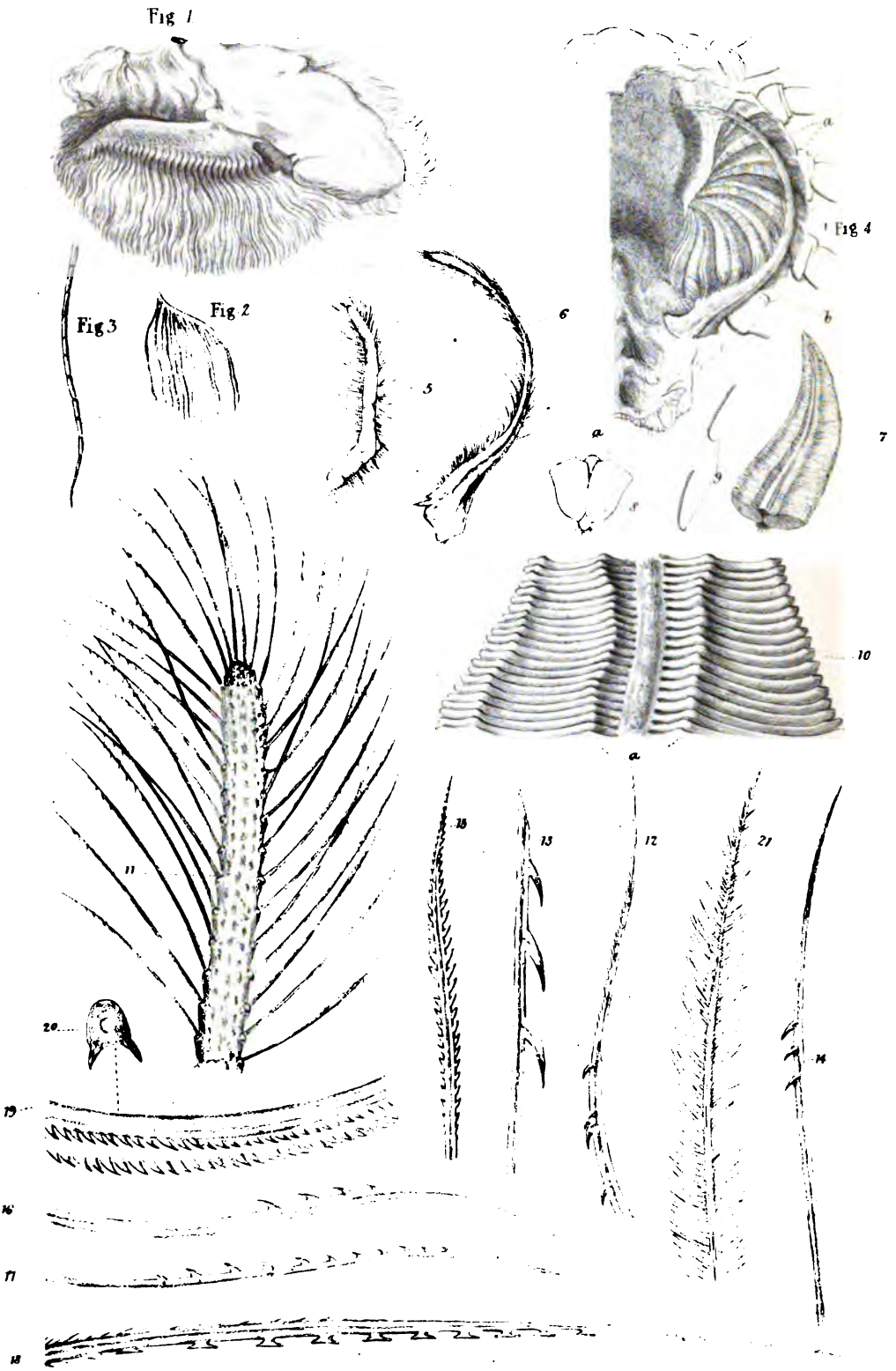

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EXPLANATION OF PLATE III.

Fig. 1. One of the branchiæ of a *Squilla*, with parallel tubes.
Fig. 2. A parallel tube, with a number of smaller tubes coming from it.
Fig. 3. One of the tubes from fig. 2, more highly magnified.
Fig. 4. Branchial cavity of a common crab, *Cancer pagurus*.
a. Branchiæ.
b. Flabellum.
Fig. 5. One of the flabella situated on the lower part of branchiæ.
Fig. 6. Flabellum from between the two rows of branchiæ.
Fig. 7. Branchia of the *Cancer pagurus*, natural size.
Fig. 8. Two of the conjoined lamellæ of the preceding preparation.
a. The spines.
Fig. 9. Hairs from the same.
Fig. 10. Branchia of the same crab magnified 175 diameters.
a. The spines.
Fig. 11. Portion of a flabellum magnified 175 diameters.
Figs. 12, 13, 14, 15, 16, 17, 18. Hairs from the flabella of various small crabs.
Fig. 19. Portion of a hair from the flabellum of the common crab, shewing two rows of spines.
Fig. 20. A transverse section of the same.
Fig. 21. Ordinary hair of the *Crustacea*.

EXPLANATION OF PLATE IV.

Fig. 1. The branchial organs of the common lobster, showing the branchia *a*, *a*, and the flabella *b*, *b*.
Fig. 2. Branchia of the lobster, natural size, with the free extremities of the tubes shown.
Fig. 3. Branchia of the same lobster, showing the points of attachment of the tubes.
Fig. 4. Branchia and flabellum attached.
Fig. 5. A portion of a branchia magnified 175 diameters.
Fig. 6. A similar preparation seen edgeways.
Fig. 7. A transverse section of a branchia.
Fig. 8. One of the tubes highly magnified.
Fig. 9. Flabellum of a lobster.
Fig. 10. Flabellum of a large cray-fish.
Fig. 11. Portion of fig. 9 magnified 175 diameters.
Figs. 12, 13, 14. Hairs from the flabellum of a lobster.
Fig. 15. Hair from the tail of an ordinary lobster.
Figs. 16 & 17. Hairs from the flabella of the large cray-fish.

IX. — *On a method of mounting objects in Canada Balsam.* By Thomas Boys, Esq. Communicated by J. S. Bowerbank, Esq.

(Read May 21, 1845).

Having had some experience in laying down objects in balsam for the microscope, and finding that I succeed uniformly without air-bubbles, I have adopted your suggestion, of giving a short detail of the method I pursue, in the hope it may be acceptable to persons who may perhaps be induced to make the experiment, and so improve upon my plan.

The first thing to be considered is the simple apparatus required.

1. A small single-wick oil lamp, having a glass chimney about four inches long. The flame to be about the size of that used in a small hand-lantern.
2. Slips of glass of required size, and small pieces of thin glass to cover the object;—all well cleaned.
3. A pair of nippers, to hold the slips of glass.
4. A pointed iron piercer, in a wooden handle.
5. A bottle, containing the clearest Canada balsam, diluted with the best spirits of turpentine, to a consistency to allow it to drop readily from the end of the iron piercer.

The preceding articles being spread before you, ready for use, and the object to be displayed being well examined for choice of position, and cleansed if necessary, fix the slip of glass in the nippers; dip the end of the piercer about half-an-inch into the balsam, when (after losing a large portion before it can be withdrawn) there will remain a full drop to place upon the slide where required. The centre of the slide should now be rested across the chimney of the lamp, until the balsam *begins to spread*, when it should be immediately withdrawn. The object is now to be placed upon this drop of balsam; the piercer is again to be dipped into the bottle, and another drop (a single drop is generally sufficient) of balsam is to be withdrawn, and to be let fall upon the object so as to well cover it. In this state the slide may be suffered to remain (covered, in order to keep away dust) for two or three minutes or more, so as to give the balsam time to penetrate; the thin glass is then to be taken up between the thumb and fore-finger, and gently placed, as nearly horizontal as possible, upon the

balsam covering the object. The slide being now held by the nippers at one end, in rather an inclined position upwards, place the other end over the centre of the chimney of the lamp, so that the extreme end of the glass may first receive the heat, which will thus gradually extend towards the object. The proof of its having done so, efficiently and sufficiently, will be that the balsam will have flowed (for that moiety at least nearest towards the heat) to the extreme edge of the thin glass, carrying out with the surplus *all air-bubbles.* The heated end of the slide is now to be placed in the nippers, and the reverse end of the glass is to be subjected to the same process, when the like result will be exhibited. The slide is then to be immediately withdrawn from the flame, and should be suffered to remain in a horizontal position till nearly cool, when a small piece of wood, rather pointed, should be pressed, perpendicularly, upon the centre of the upper or thin glass; this will expel all superfluous balsam, and with it any extraneous matter. Should it happen, after the above process, that any air-bubbles should be generated by the object, which sometimes happens, the slide should be put aside for a day or two, when they will all disappear. If the balsam require hardening, place the slide for two or more days upon the mantel-piece, the gentle heat of which will be sufficient for that purpose.

Should this simple detail be found useful to any of the microscopic fraternity of which I am so humble a member, it will afford me the greatest pleasure.

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X.—*On the Intimate Structure of Bone, as composing the Skeleton in the four great Classes of Animals, viz., Mammals, Birds, Reptiles, and Fishes, with some Remarks on the great Value of the Knowledge of such Structure in determining the Affinities of Minute Fragments of Organic Remains.* By JOHN QUEKETT, Assistant Conservator of the Museum of the Royal College of Surgeons of England.

(Read March 18, 1846).

PROFESSOR Owen, when President of this Society, in his first annual address, delivered on the 15th of February, 1841, after alluding to the great importance derived from the use of the microscope, in determining the structure and affinities of minute fragments of fossil wood, goes on to say, "And if the microscope be thus essential to the full and true interpretation of the vegetable remains of a former world, it is not less indispensable to the investigator of the fossilized parts of animals. It has sometimes happened that a few scattered teeth have been the only indications of animal life throughout an extensive stratum; and when these teeth happened not to be characterized by any well-marked peculiarity of external form, there remained no other test by which their nature could be ascertained, than that of the microscopic examination of their intimate tissue. By the microscope alone could the existence of keuper-reptiles in the lower sandstones of the new red system, in Warwickshire, have been placed beyond a doubt.

"By the microscope, the supposed monarch of the Saurian tribes—the so-called *Basilosaurus*—has been deposed, and removed from the head of the reptilian to the bottom of the mammiferous class. The microscope has degraded the *Saurocephalus* from the class of reptiles to that of fishes; it has settled the doubts entertained by some of the highest authorities in palæontology as to the true affinities of the gigantic Megatherium, and by demonstrating the identity of its dental structure with that of the Sloth, has yielded us an unerring indication of the true nature of its food."

Now if this be true of the structure of the teeth, which the brilliant results that Mr. Owen has obtained, by carrying out this mode of in-

vestigation, have abundantly proved, why—I may ask—should not minute fragments of the other parts of the skeletons of extinct animals afford us, by the same method of manipulation, some indication of the particular class to which such fragments belong?

Having paid considerable attention to the minute structure of bones for several years past, and finding that there were certain characters peculiar to each great class which could be easily recognised, I have allowed no opportunity to pass without trying to determine, by microscopic examination, how far I could proceed with my investigations with certainty; and, to show the value of such investigations, I may mention the first result.

It happens, by a singular coincidence, that two years ago, this very day, my friend Dr. Falconer, the distinguished palæontologist of the Himalaya Mountains, having in his possession certain small bones of unusual form, from which circumstance he was at a loss to determine to what animal they belonged, I, at his request, made a microscopic examination of some sections of them, and comparing their intimate structure with that of other bones in my possession, was enabled to pronounce them reptilian, and to belong probably to an animal of the turtle order; and they subsequently proved to be the toe-bones of his *Colossochelys Atlas*, or gigantic Tortoise, nearly 20 feet in length. Encouraged by this success, I have, since then, extended my researches, and have found that, in each of the four great classes of animals, the bone-cells present certain peculiarities in their form, which, when once an observer is conversant with, he would be enabled to satisfy himself as to the true affinities of doubtful specimens of organic remains.

The microscope has, in skilful hands, already achieved wonders, but much remains still to be done, in this, as yet, uncultivated field; I have, therefore, ventured to bring the subject before the notice of the Society this evening, deeming it worthy of the attention of every individual who may be engaged in the pursuit of palæontology, geology, anatomy, or any of the collateral sciences: for when satisfactory evidence of the affinities of fossil bones cannot be obtained from external features alone, there are yet present in the minute structure certain characters which may materially assist the observer in the determination, if not at once fix their true position in the scale of animated beings. I need not dwell, at this time, on the conflicting statements which have so frequently been published, concerning the true nature of certain fossil bones, most, if not all, of which statements would probably never have appeared, had the intimate structure of the bones in dispute been well

understood, and a minute fragment would have sufficed for this purpose. Before coming, however, to the immediate object of this paper, it will be necessary that I point out to you briefly the different parts of which a bone may be said to consist; and, as there are many members of our small community who do not practise the healing art, and have not, therefore, made the intimate structure of the animal body their particular study, I trust that, by a slight description, I shall be enabled to render the subject of which I am about to treat perfectly intelligible to all.

Every bone may be said to consist of two parts, a hard and a soft part: the hard is composed of carbonate and phosphate of lime, and of carbonate and phosphate of magnesia, deposited in a cartilaginous or other matrix; whilst the soft consists of that matrix, and of the periosteum which invests the outer surface of the bone, and of the medullary membrane which lines its interior or medullary cavity, and is continued into the minutest pores. If we take for examination a long bone of one of the extremities, say a femur, of a human subject, or of any mammalian animal, we shall find that it consists of a body or shaft and two extremities: if a vertical section of such a bone be made, we shall also find that the middle of the shaft contains a central cavity, termed the medullary cavity, which extends as a canal throughout the whole of it, or else is entirely or partially filled up with a cellular bony structure, which cells are termed cancelli, and the structure a cancellated structure. On a more careful examination of the bony substance or shaft, we shall find it to be slightly porous, or rather occupied, both on its external and internal surfaces, by a series of very minute canals, which, from their having been first described by our countryman Clopton Havers, are termed to this day the Haversian canals, and serve for the transmission of blood-vessels into the interior of the bone. Further than this we cannot proceed in our investigation without optical assistance; but if now a thin transverse section of the same bone be made, and be examined by the microscope with a power of 200 linear, we shall see the Haversian canals very plainly, and around them a series of concentric bony laminæ, from three to ten or twelve in number. If the section should consist of the entire circle of the shaft, we shall notice, besides the concentric laminæ around the Haversian canals, two other series of laminæ, the one around the outer margin of the section, the other around the inner or medullary cavity. Between the laminæ is situated a concentric arrangement of spider-like looking bodies, which have, by different authors, received the names of osseous corpuscles, calcigerous cells,

lacunæ or bone-cells, according as to whether they were ascertained to be solid or hollow: these bone-cells, for this is the term which I shall apply to them, have little tubes or canals radiating from them, which are termed canaliculi by some authors, and tubes and pores by others: those bone-cells which are nearest the Haversian canals have the canaliculi of that side radiating towards and opening into the Haversian canals, whilst the canaliculi of the opposite side communicate or anastomose with those of the layer of canaliculi more external to them, and those in the outer row have most of their canaliculi given off from that side of the bone-cell which is nearest its own Haversian canal; hence arises the transparent white line which often may be noticed as surrounding each concentric system of laminæ and bone-cells: in some cases, however, part of the bone-cells of the external row anastomose with another series of bone-cells, which are situated between the concentric laminæ. The average length of the lacunæ or bone-cells in the human subject is the $\frac{1}{2000}$th of an inch: they are of an oval figure, and somewhat flattened on their opposite surfaces, and are usually about one-third greater in thickness than they are in breadth; hence, as will be presently shown, it will become necessary to know in what direction a specimen is cut, in order to judge of their comparative size. The older anatomists supposed them, from their opacity, to be little solid masses of bone; but if the section be treated with spirits of turpentine, coloured with alkanet root, or if it have been soaked in very liquid Canada balsam for any great length of time, it can then be unequivocally demonstrated that both these substances will gain entrance into the bone-cells through the canaliculi. The bone-cells, when viewed by transmitted light, for the most part appear perfectly opaque, and they will appear the more opaque the nearer the section of them approaches to a transverse one; for when the cells are cut through their short diameter, they are often of such a depth that the rays of light interfere with each other in their passage through them, and darkness results, whereas if the section be made in the long diameter of the cells, they will appear transparent. When viewed as an opaque object, with a dark ground at the back and condensed light, the bone-cells and canaliculi will appear quite white, and the intercellular substance, which was transparent when viewed by transmitted light, is now perfectly dark. It happens in most, if not all, fossil bones, that the bone-cells, however much they may have been soaked in turpentine, or even boiled in Canada balsam, are nevertheless still opaque: this arises from the earthy matter, in which they have been so long imbedded, having gained entrance into the

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bone-cells through the canaliculi: this even happens in the bones of mummies, where, as Mr. Smee has shown, the bone-cells are frequently full of the bituminous and other matters with which the bodies were prepared. The structure between the bone-cells, which, with perfect consistency, may be called the intercellular substance, by an ordinary magnifying power, appears to be homogeneous; but under higher powers, as Mr. Tomes has described, it will be found to be minutely granular, the granules varying in size from $\frac{1}{6000}$ to $\frac{1}{14000}$ of an inch: they can be readily seen in a bone which has long been subjected to the action of boiling water or steam, the granules being, in fact, the true ossific matter of the bone. If a vertical section be prepared, in a similar manner to the horizontal one just described, and be examined with the same power, we shall find that the Haversian canals, for the most part, take a longitudinal direction, and that the bone-cells also assume a linear arrangement. Some few of the Haversian canals run at right angles to the section, and these communicate with the openings previously noticed, both on the exterior and interior of the shaft. Thus much may be said to compose the hard part of bone; we must now turn our attention to the soft part. This, as has been before stated, consists of the periosteum, which invests the outer, and of the medullary membrane, which invests the inner surface, lines the Haversian canals, and is continued from them, through the canaliculi, into the interior of the bone-cells, and of the cartilaginous or other matrix which forms the investment of the minute ossific granules. The earthy matter of the bone may be readily shown by macerating the section for a short time in a dilute solution of caustic potash; but the granules, according to Mr. Tomes, may be best obtained by subjecting bone to high-pressure steam, or to a red heat, till the animal matter is removed, the mass may then be reduced to powder, and a little dilute acid added, which will destroy all the broken granules before the entire ones are at all affected.

The animal matter may be procured by using dilute muriatic acid instead of caustic potash, when the earthy matter will be removed, and the section will exhibit nearly the same form as when the earthy constituent was present; and when viewed microscopically, it will be noticed that all the parts characterizing the section, previous to its maceration in the acid, will be still visible, but not so distinct as when both constituents were in combination. When, however, the animal matter is removed, the bone will not exhibit the cells and the canaliculi, but will be opaque and very brittle, and exhibit nothing but the Haversian canals and a granular structure.

If we consider what has been already mentioned as entering into the composition of a bone, viz., the medullary cavity, the Haversian canals, the canaliculi, and the bone-cells, we shall find that every part thus described has been more or less hollow; where, then, is the true bony substance? This is no other than the small granules of ossific matter which are situated between the canaliculi of the bone-cells, each granule having an investment of soft animal matter, by which the whole mass of granules is kept in firm apposition.

The parts, then, which a transverse or a longitudinal section of a long bone of a mammalian animal will exhibit, will be the Haversian canals, the concentric bony laminæ, the bone-cells and their canaliculi, although all these parts, except the bony laminæ, may be seen in all mammalian bones, whether long or otherwise; they are, nevertheless, so differently arranged in the flat bones, such as those of the skull, and in the irregular bones, such as the vertebræ, as to require a short description at this stage of our enquiry.

The bones of the cranium are, in all cases, composed of two thin layers, of compact texture, which enclose another layer of variable thickness, which is cellular or cancellated. The two outer layers are called tables, the one being the outer, the other the inner table, and the middle or cancellated layer is termed the diploë: in this last the principal blood-vessels ramify. The outer table of the skull is less dense than the inner; the latter, from its brittleness, is termed by anatomists the vitreous table. When a vertical section of a bone of the skull is made, so as to include the three layers above mentioned, bone-cells may be seen in all, but each of the three layers will differ in structure: the middle or cancellated structure will be found to resemble the cancellated structure in the long bones, viz., thin plates of bone, with one layer of bone-cells without Haversian canals; the outer layer will exhibit Haversian canals of large size, with bone-cells of large size and a slightly laminated arrangement; but the inner or vitreous layer will be found to resemble the densest bone, as the outer part of the shaft of a long bone for instance, and will exhibit both smaller Haversian canals and more numerous bone-cells of ordinary shape around them. The same thing will hold good of the ribs, scapula, and os innominatum, and of the irregular bones, such as the vertebræ, the small bones of the wrist, and ankle-joints, they being, in fact, nothing more than a cancellated or spongy tissue, enclosed by a compact layer of denser bone. It will be noticed that the bone-cells in all these bones are less regular in their size than in the long bones, and hence there will be required more caution before pro-

nouncing an opinion upon them; but luckily for the microscopist, the denser parts of fossil bones are the last to be destroyed, and every fragment he is likely to meet with will almost be certain to contain a spot where the cells present their normal characters.

In birds the majority of the bones are hollow, and the solid walls thin, but very compact in structure: the medullary cavity of the shaft of the long bones, which in Mammalia is either filled with marrow or with a cancellated tissue, is, in birds, often smooth, and is lined by a membrane, which is a continuation of that membrane which forms the air-cells of the lungs, and which gains admittance into the interior of the bones by a large opening, termed the pneumatic foramen, which is situated in the proximal extremity of each long bone: the extremities of the bones are not so thickly cancellated as those of the Mammalia, but the cancelli are supplied by small tubes of bone, which shoot across from one side of the wall to that of the other, like so many little pillars; everything being wisely arranged with an evident view to as much lightness as is compatible with strength. In those birds whose wings are not destined for flight, the pneumatic foramen still exists in some of the long bones, but is absent in others. In all these birds the solid walls of the bones are much thicker, and the medullary cavity is more cancellated: to such an extent does this thickening of the walls take place, that in the Penguin nearly every bone in the body is solid, and in the Apteryx not a bone is permeated by air. The bony matter, although sparingly used, is of greater specific gravity in birds than in any of the other classes of animals, in consequence of there being a larger amount of earthy matter in it; and in some bones, where the foramen exists, it almost rivals, in density and in whiteness, the purest ivory; whilst in others, where the foramen is absent, the bony matter is of a yellow colour, from the oily matter contained in the medullary cavity.

A transverse section of the long bone of a bird, when contrasted with that of a mammal, will exhibit the following peculiarities. The Haversian canals are much more abundant and much smaller, and they often run in a direction at right angles to that of the shaft, by which means the concentric laminated arrangement is in some cases lost; the direction of the canals often follows the curve of the bone; the bone-cells also are much smaller and much more numerous, but the number of canaliculi given off from each of the cells is much less than from those of mammals: the average length of a bone-cell of the Ostrich is $\frac{1}{2000}$th of an inch, the breadth $\frac{1}{6000}$th.

In the thin crania of the small birds the Haversian canals are

absent, and the bone-cells are very numerous, but the canaliculi proceeding from them are very few in number, and the granular matter is very well seen; but when the crania are thicker, there are two plates of bone, each containing bone-cells, with a system of Haversian canals between, forming a diploë or cancellated structure. In some of the small birds, I have noticed that small tubes of bone, each provided with the characteristic bone-cells, extend inwards towards the dura mater, but the precise office which these tubes perform I cannot at present determine. A striking contrast between the transverse section of the long bone of a bird and that of a mammal will be exhibited when they are viewed with a power of about 50 linear; that of the mammal will show the Haversian canals with the concentric laminæ around them, whilst that of the bird will appear to be composed of large curved laminæ, which follow the direction of the outer margin of the bone which is due to the Haversian canals, running for the most part transversely: the concentric arrangement around the Haversian canals, like that of the Mammalia, is only to be seen when the canals run at right angles to the section.

In the Reptilia, the bones may be either hollow, cancellated, or solid, and, generally speaking, whichever form prevails, the bone may be said to be very compact and heavy, but the specific gravity not so great as that of birds or mammals. The short bones of most of the Chelonian reptiles are solid, but the long bones of the extremities are either hollow or cancellated: the ribs of the serpent tribe are hollow, the medullary cavity performing the office of an Haversian canal; the bone-cells are accordingly arranged in concentric circles around the canal. The vertebræ of these animals are solid, and the bone, like that of some of the birds, is remarkable for its density and its whiteness. When a transverse section is taken from one of the long bones, and contrasted with that of a mammal or bird, we shall notice at once the differences which the reptile presents; there are very few, if any, Haversian canals, and these of large size; and at one view, in the same section, we shall find the canals and the bone-cells arranged both vertically and longitudinally: the bone-cells are most remarkable for the great size to which they attain; in the turtle they are $\frac{1}{375}$th of an inch in length: the canaliculi, too, are extremely numerous, and are of a size proportionate to that of the bone-cell. In most bones, especially the flat bones, or thin plates taken from any of the flat bones, the cells are arranged most frequently in parallel rows, without any Haversian canals: the canaliculi are of very large size, and are remarkable for their numerous bifurcations;

their ramifications are so thickly grouped together, that in very thin and uncut fragments of bone, they form so close a net-work over the bone-cells as almost to obscure them by their opacity. The surface of such bones will present a minutely-dotted appearance, which is caused by the numerous canaliculi which open upon it. If the section be very thin, it may be seen that the dots are really perforations of the bone. The cells attain their greatest length in the compact bones, such as those of the extremities, but in the flat bones they are, generally speaking, much shorter and broader; and if the bone be a recent one the contents of the cells may be distinctly seen. It will often happen that in a transverse section there may be noticed cells which appear at first sight like those of the Mammalia, they being of a rounded figure, and having their canaliculi arranged like those of the latter class. When they are more carefully examined, it will be found that they are nothing more than long cells cut across their short diameters.

In fishes we have a greater variation in the minute structure of the skeleton than in either of the three classes already noticed; and there are certain remarkable peculiarities in the bones of fishes, which are so characteristic, that a bone of one of these creatures can never be confounded with that of any animal of a higher class, when once the true structure has been satisfactorily understood. We lose now those characters which were evident in mammals and birds, and often, to a certain degree, in reptiles, viz., the concentric laminated arrangement of the bony matter, with a corresponding concentric arrangement of bone-cells around the Haversian canals; and we shall find that the true Haversian canals may be even absent in some fishes, their place being supplied by numerous layers of bone-cells. All the varieties of structure in the bones of fishes which I have yet made out may be referred to one of the following heads: by far the greater number of bones exhibit nothing more than a series of ramifying tubes, like those of teeth; others exhibit Haversian canals, with numerous fine tubes or canaliculi, like ivory tubes, connected with them; others consist of Haversian canals with fine tubes and bone-cells; whilst a rare form, found only as yet in the sword of the Sword-fish (*Istiophorus*), exhibits Haversian canals and a concentric laminated arrangement of the bone, but no bone-cells. The Haversian canals, when they are present, are of large size and very numerous, and then the bone-cells are, generally speaking, either absent or but few in number, their place being occupied by tubes or canaliculi, which are often of large size. The bone-cells are remarkable for their quadrate figure, and

for the canaliculi which are derived from them being few in number: they are readily seen to anastomose freely with the canaliculi given off from neighbouring cells; and if the specimen under examination be a thin layer of bone, such as the scale of an osseous fish, from the cells lying nearly all in one plane, the anastomosis of the canaliculi will be rendered beautifully distinct. In the majority of the bones of fishes the cells are not present, their place being occupied (as has been before stated) by enlarged canaliculi or tubes; but in all the hard bones, the enlarged tubes and the cells together, or else the cells alone, will be found. In the hard scales of many of the osseous fishes, such as the *Lepidosteus* and *Callicthys*, and in the spines of the *Siluridæ*, the bone-cells are very beautifully seen: in the true bony scales composing the exo-skeleton of the cartilaginous fishes the bone-cells are to be seen in great numbers. In the spines of some of the Ray family I have noticed a peculiar structure; the Haversian canals are large and very numerous, and communicating with each canal are an infinite number of wavy tubes, which are connected with the canals in the same manner as the dentinal tubes of the teeth are connected with the pulp cavity; and if such a specimen were placed by the side of a section of the tooth of some of the Shark tribe, the discrimination of one from the other would be no easy matter. In the spine of a Ray the analogy between bone and the ivory of the teeth is made more evident, for in this fish we have tubes, like those of ivory, anastomosing with the canaliculi of bone-cells. In the scales, too, of the Dog-fish, and in a species of Shark, termed the *Squalus galeus* or tope, I have noticed a similar analogy to the dental structure; in the same animals the bone-cells are absent, but, as in the dental structure, their place is supplied by ramifying canaliculi or tubes. As a general rule, I may notice that in scales and other thin plates of fishes' bone the cells are of a quadrate figure, but in the bones composing the internal skeleton they are much more elongated, like those of the Reptilia, but the cell is never so broad or so long, neither are the canaliculi so numerous as those of the latter class. In Plate vii. fig. 4, may be seen some of the cells which approach nearest those of reptiles, but still the eye will detect many differences between them and those in fig. 3.

Having said thus much on the minute structure of the bone composing the skeleton in the four vertebrated classes, let us proceed at once to the application of the facts which have been laid down; and let us, for example, suppose that a fragment of bone of an extinct animal be the subject of investigation. It has been stated, that the

bone-cells in Mammalia are tolerably uniform in size, and if we take $\frac{1}{2000}$th of an inch as a standard, the bone-cells of birds will fall below that standard, but the bone-cells of reptiles are very much larger than either of the two preceding, and those of fishes are so entirely different from all three, both in size and shape, that they are not for a moment to be mistaken for one or the other, so that the determination of a minute yet characteristic fragment of fishes' bone is a task easily performed. If the portion of bone should not exhibit bone-cells, but present either one or other of the characters mentioned in a preceding paragraph, the task of discrimimation will be as easy as when the bone-cells exist. We have now the mammal, the bird, and the reptile, to deal with: in consequence of the very great size of the cells and their canaliculi, in the reptile, a portion of bone of one of these animals can readily be distinguished from that of a bird or a mammal: the only difficulty lies between these two last; but notwithstanding that on a cursory glance the bone of a bird appears very like that of a mammal, there are certain points in their minute structure in which they differ, and one of these points is in the difference in size in their bone-cells. I have stated that the average size of the cells in Mammalia is $\frac{1}{2000}$th of an inch, whilst in birds they are much smaller: to determine accurately, therefore, between the two, we must, if the section be a transverse one, also note the comparative sizes of the Haversian canals, and the tortuosity of their course, for the diameter of the canal bears a certain proportion to the size of the bone-cells, and after some little practice the eye will readily detect the difference. The fragments necessary for the purpose of examination are to be selected with some little care, and on the whole a small chip (or two) from the exterior of the shaft of a long bone is sufficient; but as many fossil bones are coated with a layer of earthy deposit on their external surface, it will be requisite to get beneath this deposit, as it very seldom happens that the bone-cells are visible in it, but by a fragment from about the middle of the laminæ of the shaft the characteristic bone-cells can at once be recognised. But in the comparison of the bone of a mammal with that of a bird, I prefer transverse sections, as from the peculiarity in the arrangement of the Haversian canals in the latter class, it is highly important always to bear in mind that the specimens used for comparison should be cut in one and the same direction, for as it has been stated that the bone-cells, on which we are to rely for our determination, are always longest in the direction of the shaft of the bone, it would follow, that if one section were transverse, and the other longitudinal, there might be a vast

difference in the measurement of the bone-cells, in consequence of their long diameter being seen in the one case, and their short diameter in the other; and hence the caution of having all the sections made in one direction. In all doubtful cases the better plan is to examine a number of fragments, both transverse and longitudinal, taken from the same bone, and to form an opinion from the shape of bone-cell which most commonly prevails.

If we examine minutely the excellent table of the comparative sizes of the blood-particles in the four great classes of animals, drawn up with much care and attention by Mr. Gulliver, we shall find that, with very few exceptions, the blood-particles of the human subject are much larger than those of birds measured in the short diameter, and that those of reptiles are much larger than either of the two preceding; and I have already mentioned that the bone-cells are the largest in the reptiles, the next largest in the mammal, and the smallest in the bird: now it would indeed be a curious result, if it should ultimately turn out that the bone-cells of an animal are always in proportion to the size of the blood-discs: my investigations at present are not yet in a sufficiently forward state to warrant my coming to such a conclusion, but still there are many cases in which it holds good. It is well known to anatomists, that in proportion to the size of the blood-discs so is the size of the capillaries, and as the capillaries may vary so will the size of the muscular fibres, the nervous fibres, and in fact every tissue and organ of the body, so that when the size of the blood-discs is known, some general idea may be formed of the sizes of the different component parts of the other tissues; and should this mode of generalizing ultimately prove to be applicable to the bone-cells as well, we shall be able not only to determine the class of a fossil fragment, but to predict the size of the blood-particles, and when they are once known the size and proportions of the other soft tissues may at once be inferred.

The laws of Nature are undeviating in the construction of the skeleton of vertebrate animals: the same regularity in structure, the same method of arrangement of the bone-cells, has existed from the time when the surface of our planet was first inhabited by a vertebrate animal up to the present period. The largest bones of the mighty Iguanodon (say of 100 feet in length), of the Ichthyosaurus—the tyrant of the water in former ages, of the gigantic Tortoise of the Himalaya range (some 20 feet in length), present no appreciable difference, in their minute structure, from the pigmy race of lizards that we now tread under our feet. The bones of the

gigantic *Dinornis* exhibit no difference in structure from those of its now only existing representative, the *Apteryx*. The bones of the Mastodon and the huge Megatherium, the giants of the land, are no more remarkable for the coarseness of their structure than are those of the smallest of the mammiferous quadrupeds, the mouse, and such has been the prevailing law from the commencement of the earth's existence, and such, no doubt, will continue to the end of time.

MEASUREMENT OF BONE-CELLS IN PARTS OF AN ENGLISH INCH.

TRANSVERSE SECTIONS.

HUMAN . . .	Long diameter,	one of the largest,	$\frac{1}{1700}$.
		one of the smallest,	$\frac{1}{2700}$.
	Short diameter,	one of the largest,	$\frac{1}{4000}$.
		one of the smallest,	$\frac{1}{6000}$.
OSTRICH . .	Long diameter,	one of the largest,	$\frac{1}{1333}$.
		one of the smallest,	$\frac{1}{2250}$.
	Short diameter,	one of the largest,	$\frac{1}{3625}$.
		one of the smallest,	$\frac{1}{5650}$.
TURTLE . . .	Long diameter,	one of the largest,	$\frac{1}{875}$.
		one of the smallest,	$\frac{1}{1750}$.
	Short diameter,	one of the largest,	$\frac{1}{2500}$.
		one of the smallest,	$\frac{1}{3850}$.
CONGER EEL .	Long diameter,	one of the largest,	$\frac{1}{850}$.
		one of the smallest,	$\frac{1}{1725}$.
	Short diameter,	one of the largest,	$\frac{1}{2500}$.
		one of the smallest,	$\frac{1}{3850}$.

XI.—*Additional Observations on the Intimate Structure of Bone.* By JOHN QUEKETT, Assistant Conservator of the Museum of the Royal College of Surgeons of England.

(Read November 11, 1846).

IN a paper which I laid before this Society at the meeting held March 18th, 1846, entitled, "On the Intimate Structure of Bone, as composing the Skeleton in the four great Classes of Animals, viz., Mammals, Birds, Reptiles, and Fishes, with some Remarks on the great Value of the Knowledge of such Structure in determining the Affinities of Minute Fragments of Organic Remains," after describing briefly the various parts of which the shaft of a long bone of the Mammalia is composed, viz., 1st, a central or medullary cavity,—2ndly, a series of small canals (Haversian), around which are arranged concentric laminæ of bony matter,—3rdly, of a concentric arrangement of spider-like looking bodies, which have been variously termed osseous corpuscles, calcigerous cells, lacunæ or bone-cells, each cell having little tubes or canals, termed canaliculi, proceeding from them,—I went on to show that the average length of the bone-cells in the human subject was about $\frac{1}{1000}$th of an inch, that they were of an oval form, somewhat flattened on their opposite surfaces, and usually one-third greater in thickness than in breadth; that the bones of birds were all more or less hollow, and the Haversian canals much smaller and more numerous than in Mammalia, that the bone-cells also were of much smaller size, and their long diameters often placed at right angles with the shaft of the bone; that in the Reptilia the Haversian canals are large and not numerous, but the bone-cells and their canaliculi are remarkable for their very large size, whilst in fishes the Haversian canals were entirely absent in some bones, and abundant in others: when entirely absent, their place appeared to be supplied by bone-cells which presented several peculiarities, serving to distinguish them from those of the mammal, the bird, or the reptile, they being, for the most part, of a quadrate figure, and the canaliculi given off from them but few in number, and readily seen to anastomose freely with the canaliculi from other cells. I then proposed to apply the characters derived from the bone-cells to the determination of the class of animals to which any minute fragment of fossil or other bone

may have belonged. I also stated that anatomists had long been familiar with the fact, that in proportion to the size of the blood-corpuscles so is that of the capillaries, and of the muscular and nervous fibres; and it would appear that the same thing held good with respect to the bone-cells. From the highly valuable table of the comparative sizes of the blood-discs, published by Mr. Gulliver, we learn, that the blood-particles are largest in reptiles, smallest in Mammalia and birds, and in fishes of an intermediate size; and it has been already stated, that the bone-cells are largest in reptiles, and are much smaller in Mammalia and birds; hence it would appear, that the bone-cells are subject to the same law as the capillary, muscular, and other systems; and in the advanced stages of the inquiry, it may possibly turn out, that if one or other of these systems be known the size of the others may be readily inferred.

Since my last communication, of which the preceding is a brief abstract, I have extended my researches to the investigation of the minute structure of the bone of those Reptilia in which the blood-particles are the largest, and have taken as examples some of the perennibranchiate Reptilia, viz., the Siren, the Proteus, the Menopome, the Menobranchus, and the Axolotl, and the result of the examination has been highly satisfactory, for I find, as I had predicted, that the bone-cells would be the largest in those animals which had the largest blood-discs. In the Siren they appear to have attained their greatest size; and this reptile, as far as I can learn, has larger blood-discs than any other existing animal: the portions of bone examined were taken from the skull, and from a vertebra, and these fragments exhibit cells of enormous size; some of them are oval, others of a quadrilateral figure, with very large but not very numerous canaliculi, whilst others are not so broad, but much more elongated, and the canaliculi so numerous as to form a dense net-work around the cells, which nearly obscures them. The latter or elongated cells are chiefly found in the thick or dense portions of bone, where they are arranged in parallel rows, like those of the Turtle and Python before alluded to, whilst the former or broad cells occurs in the thinner plates of bone, and never are arranged in rows, but are scattered irregularly about; and if the bone be recent, the granular contents of the cells will be readily made out: if the specimen be a thin one, and mounted in Canada balsam, it will sometimes happen that the cells contain air, and in the process of mounting the balsam will enter the canaliculi and obscure them, and the cell will then appear like a large bubble of air, for which it has been more than once mistaken. The bones of

all the perennibranchiate Reptilia before enumerated present the same form of cells, but in none do they equal in size those of the Siren.

The structure, then, of the bone of the perennibranchiate Reptilia may be characterized by the almost entire absence of the Haversian canals, except in the large bones, and by having their place supplied by enormously long and broad, and sometimes quadrilateral, bone-cells, with large canaliculi, anastomosing freely with those of neighbouring cells: the canaliculi are large, like those of fish, but not so numerous as those of the ordinary reptiles, as may be seen by comparing figs. 4, 5, and 6, with fig. 3, in Plate vii. In fact, everything agrees with the characters presented to us by the blood of these animals. I have never yet seen the blood of the Menopome, Proteus, or Axolotl, but should infer, from the structure of their bone, that their discs or corpuscles, as they are termed, are not so large as those of the Siren. As some of the highest authorities in comparative anatomy are still at issue respecting the true class to which the Lepidosiren belongs, some regarding it as a reptile, others as a fish, I was anxious to ascertain what evidence of its true nature might be obtained from the structure of its bone; and I may here state, that a thin fragment from the base of the cranium exhibits two forms of very large cells, the one of a quadrilateral figure, like those of the Siren, the other of an elongated form, similar to those of the Turtle, but much greater in breadth: the first kind were distributed irregularly, and at wide intervals apart from each other, whilst those of the second or elongated kind were arranged in parallel rows, with a dense net-work of canaliculi around them, so dense in some parts as almost to obscure the cell: in all these characters the structure agrees with that of the bone of the perennibranchiate Reptilia just described, no cells at all resembling them having as yet been found in any of the orders of fishes. The cells of the latter animals which come nearest to those of Reptilia are depicted in Plate vii. fig. 4; they are from the Conger Eel, and are elongated like those of the Turtle, but have not the breadth, nor so great a number of canaliculi as those of the latter animal, and they are so entirely different from the cells of any of the perennibranchiate Reptilia, that not a moment's hesitation need be required to satisfy an inexperienced observer of their want of identity. The elongated cells are rarely to be found, except in the bones composing the endo-skeleton of fishes: in the scales, and other thin plates of osseous matter, the cells are of a small quadrilateral figure, and have but few canaliculi, as may be seen in Plate viii. fig. 1,

which represents a portion of the scale of the *Lepidosteus* magnified 440 diameters. The other peculiarities in the bone of fish having been mentioned in the preceding paper, and being so entirely different in structure from any other bones of the higher animals, from the fact of their having no bone-cells at all, I need not again allude to them here. The Lepidosiren, then, however much its other true ichthyic characters may prevail, may be said to be, as to the structure of its bones, more like a reptile than a fish; and thence it may be inferred, that the blood-corpuscles are nearly equal in size to those of the perennibranchiate Reptilia, to which the bone-cells are most nearly allied.

MEASUREMENT OF BONE-CELLS IN PARTS OF AN ENGLISH INCH.

MENOPOME . . .	Long diameter,	one of the largest, $\frac{1}{450}$. one of the smallest, $\frac{1}{700}$.
	Short diameter,	one of the largest, $\frac{1}{1300}$. one of the smallest, $\frac{1}{2100}$.
PROTEUS	Long diameter,	one of the largest, $\frac{1}{270}$. one of the smallest, $\frac{1}{580}$.
	Short diameter,	one of the largest, $\frac{1}{583}$. one of the smallest, $\frac{1}{1300}$.
SIREN	Long diameter,	one of the largest, $\frac{1}{295}$. one of the smallest, $\frac{1}{480}$.
	Short diameter,	one of the largest, $\frac{1}{340}$. one of the smallest, $\frac{1}{973}$.
LEPIDOSIREN . . .	Long diameter,	one of the largest, $\frac{1}{375}$. one of the smallest, $\frac{1}{474}$.
	Short diameter,	one of the largest, $\frac{1}{580}$. one of the smallest, $\frac{1}{2100}$.
PTERODACTYLE . .	Long diameter,	one of the largest, $\frac{1}{415}$. one of the smallest, $\frac{1}{1183}$.
	Short diameter,	one of the largest, $\frac{1}{2000}$. one of the smallest, $\frac{1}{3125}$.

Pl. VI.

Fig. 3 Turtle

Mag.d 95 dia.s

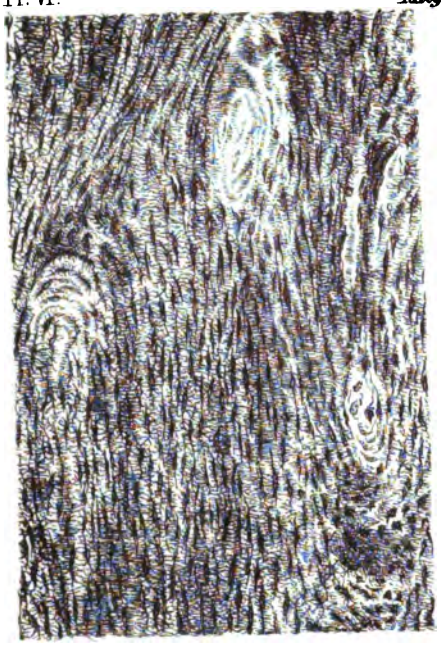


Fig. 4. Conger Eel

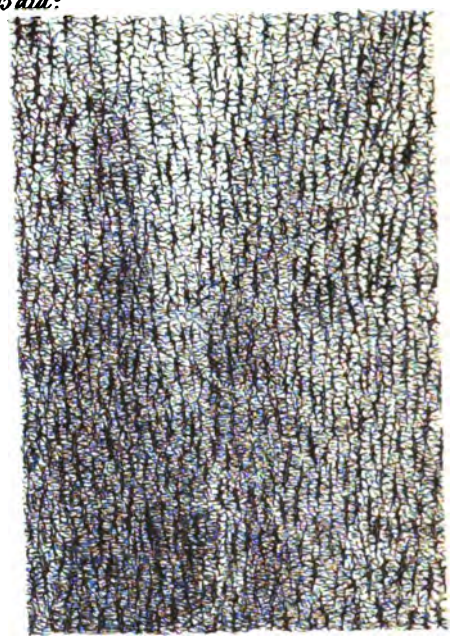


Fig. 5. Menopome.

95 dia.s

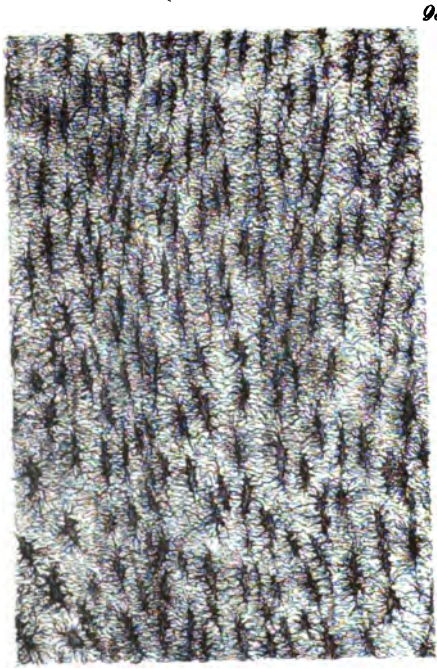
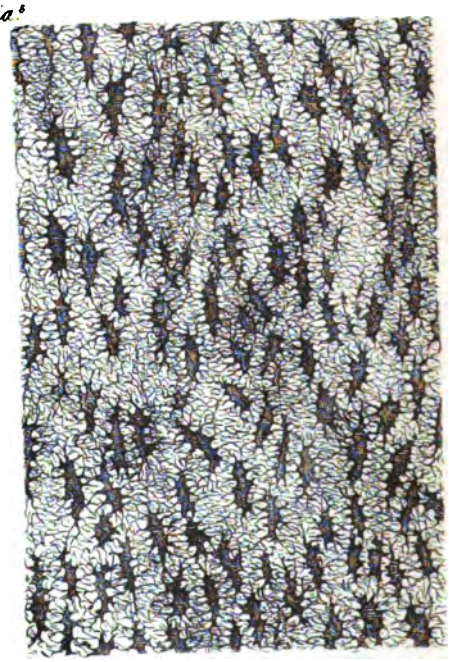


Fig. 6 Siren.



Day & Son, lith.rs to the Queen

Pl. V.

Fig. 1. Human. Magd. 95 diams.

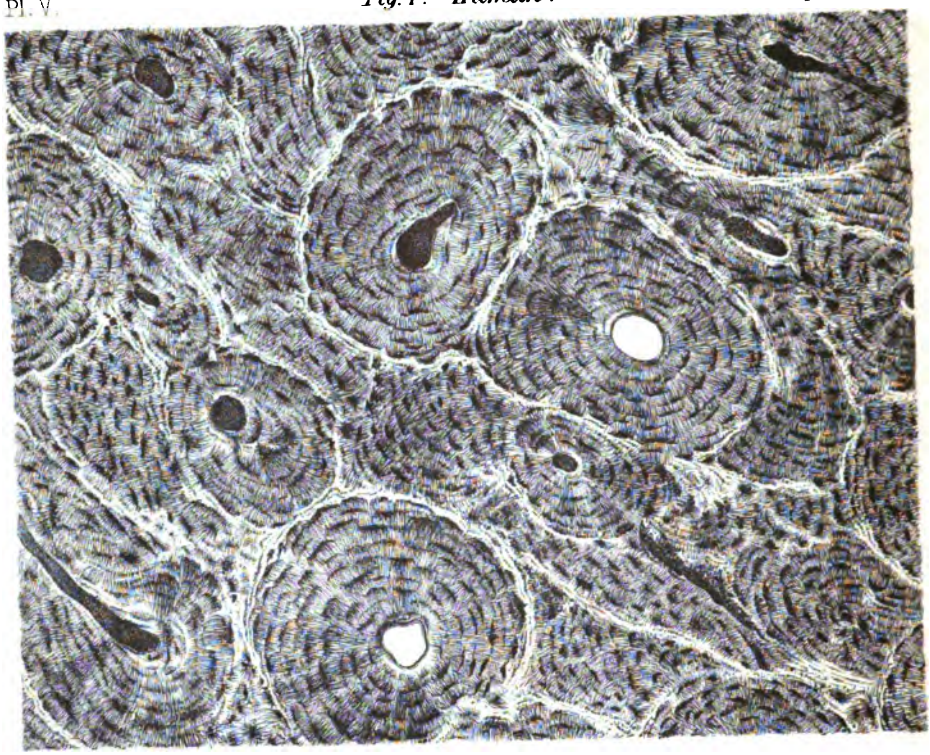
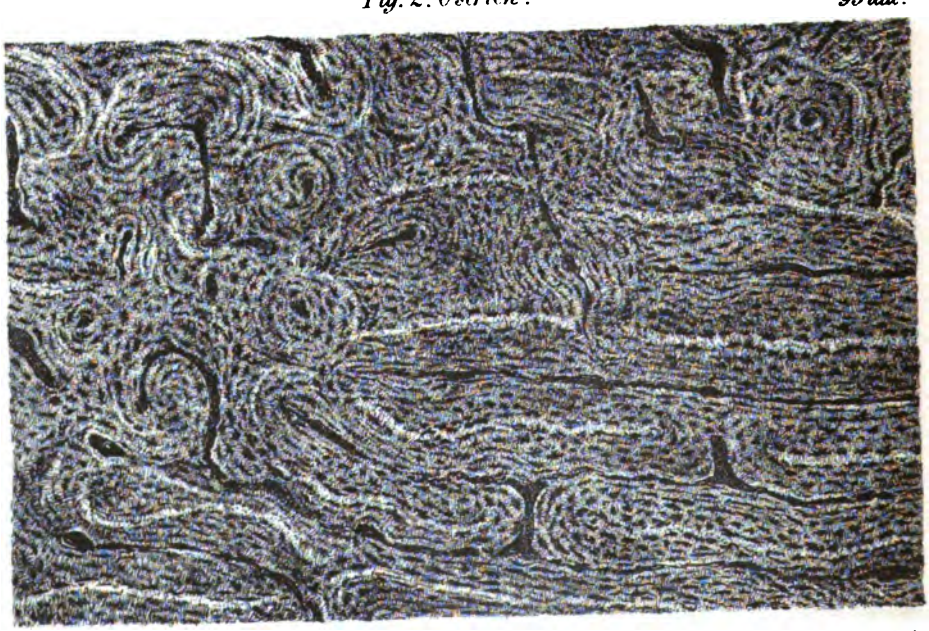


Fig. 2. Ostrich. 95 diams.



S. W. Leonard, del. et. lith.

Day & Son, lith.rs to the Queen.

EXPLANATION OF THE PLATES.

Plate V.

Fig. 1. A transverse section of the human clavicle, magnified 95 diameters, which exhibits the Haversian canals, the concentric laminæ, and the concentric arrangement of bone-cells around them. Some of the Haversian canals are white, others black; the latter are filled with a deposit of opaque matter, used in the grinding and polishing the section: the outer margin of each of the series of concentric laminæ is white and transparent, which is caused by the canaliculi of the outer row of bone-cells being given off only from one side of the cell, and that side being the one nearest its own Haversian canal.

Fig. 2. A transverse section of the femur of an Ostrich, magnified 95 diameters. When contrasted with the preceding figure, it will be noticed that the Haversian canals are much smaller and much more numerous, and many of them run in a transverse direction. The bone-cells are very much smaller, and the concentric laminated arrangement only visible where the canals run at right angles to the section. When the concentric laminæ do exist they are not so numerous as in Mammalia; rarely more than from three to five are found around any one Haversian canal.

Plate VI.

Fig. 3. A transverse section of the humerus of a Turtle (*Chelonia Mydas*). It exhibits traces of three Haversian canals, with a slight tendency to a concentric arrangement of bone-cells around them: the bone-cells are large and very numerous, but occur for the most part in parallel rows: in these rows the cells are seen in their longest diameters, whilst in the immediate neighbourhood of the Haversian canals they present their short diameters.

Fig. 4. A horizontal section of the lower jaw of a Conger Eel, which exhibits a single plane of bone-cells arranged in parallel lines: there are no Haversian canals present; and when this specimen is contrasted with that of fig. 3, it will be noticed that the canaliculi given off from each of the bone-cells of this fish are very few in number in comparison with that of the reptile.

Fig. 5. A portion of the cranium of the Menopome, which exhibits numerous bone-cells of a large size: they are arranged in parallel lines, and are much farther apart than those of the Eel or Turtle. No Haversian canal is present, but there is a disposition to a concentric arrangement, as seen on the left-hand side of the figure: at this part the bone-cells are the largest.

Fig. 6. A portion of the cranium of a Siren (*Siren lacertina*), which is remarkable for the large size of the bone-cells and of the canaliculi, they being larger in this animal than in any other yet examined; as in the preceding specimens, no Haversian canals are present.

The above four specimens are magnified 95 diameters.

Plate VII.

Fig. 1. A portion of human clavicle, magnified 440 diameters, to show the bone-cells and their canaliculi: the largest of the bone-cells are about $\frac{1}{350}$th, the shortest about $\frac{1}{1000}$th of an inch in length.

Fig. 2. A portion of the transverse section of the femur of an Ostrich, magnified 440 diameters. An Haversian canal is seen longitudinally divided, with the small bone-cells arranged in parallel lines on either side of it. The length of the bone-cells is on an average about $\frac{1}{1000}$th of an inch.

Fig. 3. A portion of the humerus of a Turtle (*Chelonia Mydas*), magnified 440 diameters, in which the elongated bone-cells with numerous canaliculi are well exhibited: the length of these bone-cells varies from $\frac{1}{350}$th to the $\frac{1}{875}$th of an inch.

Fig. 4. A portion of the lower jaw of a Conger Eel, magnified 440 diameters: the bone-cells are neither so long nor so broad as those of the Turtle, but the canaliculi are larger and less numerous. The longest bone-cell in this specimen is $\frac{1}{270}$th, the shortest $\frac{1}{1250}$th of an inch.

Fig. 5. A portion of the cranium of a Menopome, magnified 440 diameters, showing the large size of the bone-cells and the canaliculi: although many of the cells are not so long as those of the Turtle, they are nevertheless nearly twice as broad. The length of the cells varies from the $\frac{1}{350}$th to the $\frac{1}{700}$th of an inch.

Fig. 6. A portion of the cranium of the Siren (*Siren lacertina*), magnified 440 diameters. The bone-cells in this animal are the largest known; they are quite as long as those of the Menopome, and are much broader. Some of them are as much as the $\frac{1}{300}$th of an inch in length by the $\frac{1}{250}$th in breadth.

Plate VIII.

Fig. 1. A portion of the scale of the *Lepidosteus osseus*, which exhibits the quadrate form of bone-cell, with few canaliculi, which is generally found in thin plates of bone of fishes.

Fig. 2. A small portion of bone, taken from the exterior of the shaft of the humerus of a Pterodactyle, which exhibits the elongated bone-cells characteristic of the higher orders of Reptilia.

Fig. 3. A transverse section of the spine of a Silurus, which exhibits numerous branching tubes or canals, like those of teeth, but no bone-cells.

Fig. 4. A horizontal section of a scale or flattened spine from the skin of a Trygon or Sting Ray, which exhibits large Haversian canals, with numerous wavy parallel tubes, like those of *dentine*, communicating with them. It will be noticed that this specimen shows, besides these wavy tubes, numerous bone-cells whose canaliculi communicate with the tubes, as in many specimens of *dentine*.

Fig. 5. A portion of the base of the cranium of a Lepidosiren (*Lepidosiren annectens*, Owen), which shows two forms of very large bone-cells, similar to those in the Menopome and Siren and other perennibranchiate Reptilia.

Fig. 6. A portion of the base of the cranium of a Lepidosiren, magnified 95 diameters, which exhibits both the elongated and the quadrate form of bone-cells, for the purpose of comparison with those of the Menopome and Siren, in Plate vii. figs. 5 and 6, which are similarly magnified.

Pl. VII.

Mag.d 440 dia.s

Fig. 1. Human.

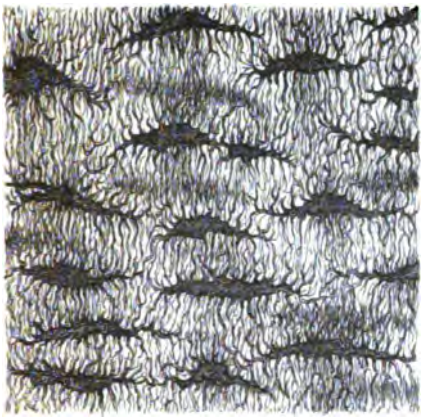


Fig. 2. Ostrich.

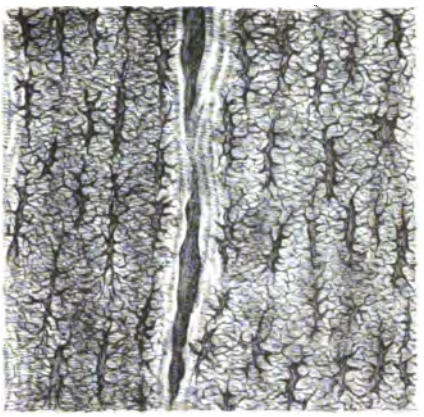


Fig. 3. Turtle.

440

Fig. 4. Conger Eel.

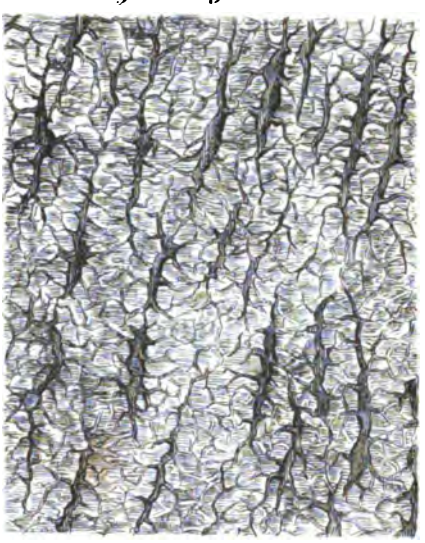


Fig. 5. Menopome.

440

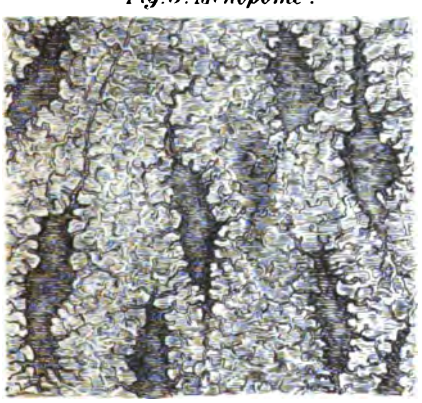
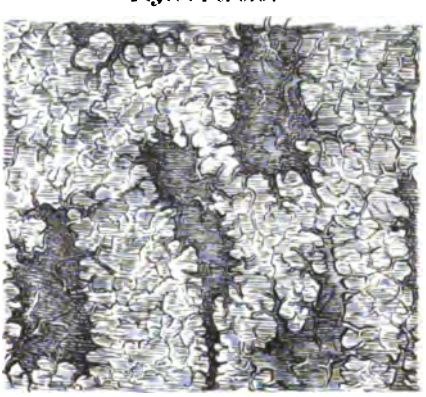


Fig. 6. Siren.



S. W. Leonard, del. et lith.

Day & Son, lith.rs to the Queen

Lepidosteus.

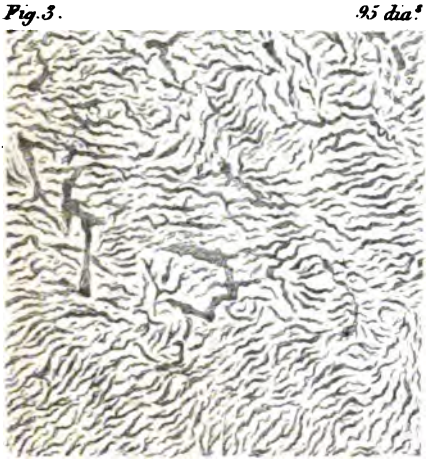
Fig. 1. 440 dia.s

Pterodactyle.

Fig. 2. 440 dia.s

Silurus.

Fig. 3. 95 dia.s

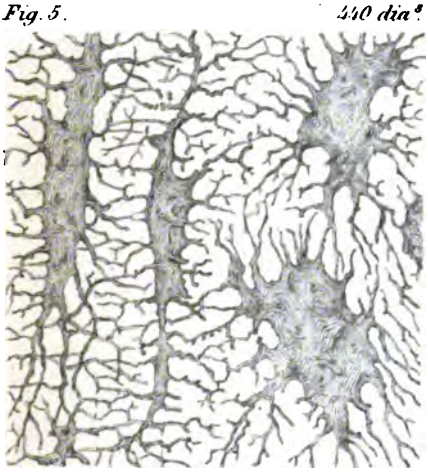


Ray

Fig. 4. 95 dia.s

Lepidosiren.

Fig. 5. 440 dia.s



Lepidosiren.

Fig. 6. 95 dia.s

S.W. Leonard, del. et lith.

Printed by Reeve Brothers

XII.—*Observations on the Structure and Nature of the Filaria medinensis, or Guinea Worm.* By George Busk, F.L.S., &c.

(Read April 15, 1846).

The subject of parasitic diseases, or the study of those morbid affections of both animals and plants, which are caused by the attacks of parasitic organisms of one or the other kingdom, is so intimately connected with microscopic research, and depends for its ultimate, complete elucidation so much upon the application of the microscope, that the following observations relative to one of the most important parasites of the human frame, may not, I hope, be considered altogether irrelevant to the objects of this Society. Having had many opportunities of observing instances of the occurrence of the Guinea worm in this country, I have arrived at some conclusions with regard to it, which, if found to be correct, will be of interest not only in the particular instance of that worm, but may perhaps analogically apply to a much greater extent among the nematoid *Entozoa*. The subject, however, as it relates to the *Filaria medinensis*, cannot be pursued to the full extent in this country, nor in Europe. It is reserved for the observer in Africa or Asia to fill up the great gaps which I believe yet exist in the complete history of this very troublesome *Entozoon*.

As, from the rarity of the occurrence of the Guinea worm here, few, even among medical men, can be presumed to be very familiar with what is already known regarding it, I may perhaps be excused, before entering upon the proper subject of this paper as it concerns microscopic research, for adverting very briefly to a few of the main points connected with the natural history of the *Entozoon*; and the more so, as all these facts in some degree tend to confirm the conclusions at which I am disposed to arrive from considerations drawn from its anatomical structure.

The *Filaria medinensis* or Guinea worm is an extremely common parasite of the human frame in those parts of the world where it is endemic. Fortunately, however, these parts are neither numerous nor very extensive. They are chiefly certain regions of tropical Africa and Asia. The proper habitation of the worm is in the torrid zone, but it is not confined to that zone, nor does it occur by any means in all tropical countries. It is met with, according to Künse-

muller, in Arabia Petræa, on the borders of the Persian Gulf and of the Caspian Sea, — on the banks of the Ganges, — in Upper Egypt, Abyssinia and Guinea. From its frequency in the latter country its vulgar name is derived, but its occurrence even there is extremely capricious. In some districts on the coast of Africa almost every native coming off to the ships is found to be affected with the worm, whilst in other places, distant only a few leagues, scarcely a trace of it will be met with. The same narrow limitation of range has also been observed in India, and the epidemic prevalence of the worm has been supposed to be connected with the periodicity of the seasons. In India, it is stated by some writers to prevail mostly in the months of November, December and January. Correct observations, however, with respect to *periodicity*, are much to be desired, with reference not only to this but to all *Entozoa*.

In America the Guinea worm is unknown, except in persons who have had communication with Africa or other parts where it is indigenous. The island of Curaçoa is the only locality in the New World which offers an apparent exception to this fact; and it would be highly desirable to ascertain the real state of the case in this instance.

Though endemic only in the above-mentioned parts of the world, it would yet appear that all races of mankind are obnoxious to the attacks of the *Filaria* when exposed to what may be called the contagion, that is, when placed in circumstances under which it might be supposed a contagious seminium could be conveyed to them. This liability is incurred, so far as I have been able to ascertain, by the exposure of the bare surface of any part of the body to water in which the infection may be supposed to reside. There is, at all events, at present no evidence of any other source of infection. I have known many instances tending to prove that, in order that a European should become infected with the Guinea worm on the coast of Africa, it is not necessary he should have been ashore at all. It has been quite sufficient for him to have exposed the bare surface of some part of his person to the water in the native canoes alongside, or, it may be, to the discharge from the sores of those labouring under the disease. This mode of its introduction accounts for the frequency with which the legs and feet are attacked by the parasite in preference to other parts of the body, as it will always, I believe, be found that the men who have become so affected have been in the habit of going about with bare feet, as is common among sailors in warm latitudes. That the contagious material is conveyed in water

is also further indicated by the well-known fact, that in India, where it is the custom for the natives to carry water in skins on their backs, the worm makes its appearance on the back and shoulders and upper part of the body. The observation that very little intercourse with the land is necessary for the conveyance of the worm, is strengthened by the statement made by Rudolphi, that it occurs in persons who have neither eaten nor drank in the countries where it is endemic, but who yet become contaminated with the seminia afterwards to be developed.

The entrance of the worm into the body is apparently unattended with any observable symptom, and the person affected is unconscious of its presence until the period when it is ready to make its exit.

The life of the worm as a *parasite* may be divided into two periods. And its existence as a whole, or until, as I suppose, its cycle of development is completed, presents at least three, and it may be, four periods or phases.

In one of these periods the worm is latent, and in the other its existence is manifested by external symptoms.

The former or latent period lasts, as I deduce from several cases in which I have had the opportunity of inquiring carefully into all particulars, from twelve to eighteen months, seldom less or more. During this period the worm resides in the cellular tissue, and probably usually at some depth from the surface, but this of course varies according to the part invaded. In the instance of which the preparation is now before you, the parasite, as you will perceive, occupies the cellular tissue immediately around the *tendo Achillis* and the lower part of the muscles of the calf of the leg. It was discovered accidentally in dissecting the leg of a negro youth from the coast of Africa, during whose life there were no indications of the worm's existence. It is to be remarked, consequently, that during the latent period the animal does not appear to exert any irritating influence upon the surrounding tissues. No mark of inflammatory or other morbid action was observable in the cellular tissue in which the worm is lodged, in the present instance.

Assuming the longer of the above-mentioned periods as the term of the animal's latency, it would follow that its growth is very rapid; for I have, in every instance that has come under my notice, found that the length of the worm has nearly reached, and in some instances has exceeded, six feet. This would give a growth of about an inch a week as its rate of increase. When the period of ripening, as it may be termed, has arrived, the worm makes its presence and

its intended exit through a perforation of the skin, known by various symptoms which it is needless here to describe. The point of exit is usually marked by circumscribed inflammation and suppuration; and the prolonged and tedious extraction of the worm is usually accompanied throughout with a good deal of suppuration and pain, according to the situation and relations of the part affected and the habit of the patient, and also in a great degree according to the mode in which the artificial extraction is proceeded with.

The worm invariably presents itself with the head first. On this account, unless an opportunity (which rarely occurs) be afforded of seeing the case before the pustule by which the point of the creature's exit is indicated be opened, the head is usually rubbed off and destroyed. Out of many cases occuring in this country I have only once succeeded in obtaining a perfect cephalic extremity of the worm. The caudal extremity is thus of course always the last to come away, and I have had abundant opportunities of examining this portion of the animal.

The whole worm, when mature and fresh, is of a transparent, milky white colour, and presents an indistinct, brownish, wavy, longitudinal streak; it is cylindrical, and about $\frac{1}{12}$ of an inch in diameter, and as I have stated, from four to six feet in length. The surface is marked by distinct and regular transverse or circular rugæ, which are more or less approximated according to the degree of extension in which the worm may be placed. In consistence it is tough and elastic to a remarkable degree; so much so, that when quite fresh, a portion admits of being elongated to nearly double its natural length. When dried the body assumes a flattened, riband shape, like all the nematoid worms with two opposite bands of muscle, and it becomes horny and transparent. The cephalic extremity is obtuse and rounded, and presents a minute oral orifice, around which the external integument appears to be thrown into radiating folds. But I have not made as accurate an examination of this part as I could have wished, owing to the difficulty of procuring specimens with that extremity in a perfect state. The body presents the characters described above. The caudal extremity is more or less acuminated, subulate and curved, as shown in Figs. 1, 2, 3, 4, 5. In consequence of the varieties presented in the form of this part, it has been formerly erroneously described as affording a distinguishing sexual character. But that, in reality, it affords no such character, is sufficiently obvious when it is remarked that all the varieties of the caudal extremity occur in individuals containing living young, and

which are consequently all of one sex. The male *Filaria medinensis* is described apparently as a matter of course by nearly all who have written on the subject. I have, however, myself never seen any other form of the worm than that in which young are contained, although I have more than once extracted two, or even three individuals from the same limb of the same person. Mr. Owen (Cyclopedia of Anatomy and Physiology, vol. ii. p. 122) remarks that the caudal extremity of the male is obtuse, and emits a single spiculum, and even gives (*l. c.*) a figure of such an individual; but with the greatest deference to so high an authority, I cannot help thinking that the appearance presented by the caudal extremity in that instance must have been deceptive, and that it is to be referred to some unusual attenuation of the acuminated point in a worm of the usual kind. Of course this is merely thrown out as a surmise, and it would be highly interesting, in fact of the utmost importance, as regards the true nature of the worm, to determine the question one way or the other. The principal view, which it is the object of this paper to exhibit, depends for its support entirely upon the non-existence of a *male Filaria medinensis* in the parasitic condition. But in venturing to make these observations upon the statement of so eminent an observer, I am glad to find myself supported by what Rudolphi says on the same point. He states (Mantissa Entozoologiæ, p. 20, 1819) "that in two specimens he had observed the caudal apex, subulate, inflexed, and a line in length; and in a third, semiterete, rather acute, subincurvated, but not subulate nor as much curved as in the others;" and he goes on to say "that being struck by the variety of the caudal extremity (which he had taken for a mark of sexual distinction, and had the more readily fallen into this erroneous notion on account of the presence of young ones in the female specimens) he had referred to the distinction of the sexes in giving the specific definition of the *Filaria*, but had ascertained by renewed examination after the synopsis was printed, that *all* the above specimens were female and proligerous."

I have not been able to perceive any anal or other orifice at the caudal extremity of the worm, nor in any part of its length, and consequently believe that none such exists.

The outer integument is white, semitransparent, firm, and of considerable thickness, highly elastic and extensible, and marked externally with transverse rugæ, as mentioned above. Whether these rugæ are dependent upon the presence of distinct circular fibres or not, I have not been able to satisfy myself completely. At first sight

the membrane appears to consist of only one layer, but when torn in different directions it is found to be composed of three or more layers of a minutely fibrous texture, the direction of the fibres in which is diagonal, so that they cross each other alternately. That the circular rugæ are owing to wrinkles of the membrane and not to circular fibres, appears probable from the fact that they disappear when the worm is forcibly extended. Immediately within this elastic integument are found two fasciculi of muscular fibres, placed on the opposite sides of the body, and which extend uninterruptedly from one extremity of the worm to the other. A portion of one of these fasciculi is represented in Fig. 6, *a*. The muscular fibre is not marked with transverse striæ. On each side of these muscular bands is a thin tract of a peculiar substance, and in the middle of each of these tracts is a more or less transparent line (Fig. 6, *b*, *b*). The substance composing the tracts is minutely granular, and presents no other aspect under the highest power I have been able to employ. The transparent line appears to be a canal excavated in the granular substance, and is without visible walls.

These tracts also extend from one end of the worm to the other, and they are evidently analogous to organs of a similar appearance present in the *Ascaris lumbricoides*, &c., and the function of which is not yet I believe understood. They may probably be connected with a nervous system, no other trace of which has been evident to my observation. The longitudinal muscular fasciculi and the lateral tracts of granular substance are placed between the outer and inner membranes or tubes which constitute the body of the worm, and they appear to be firmly adherent to the former. The internal tube is constituted of a soft, pulpy substance, covered with a delicate membrane. It forms numerous lobular, rounded folds or projections, hanging as it were into the cavity of the body, as seen in the figure of a transverse section of a portion of the body (Fig. 8), which affords a lateral view of these projections, and (Fig. 9), which represents them as seen from the inner surface. They are of a rounded form and of various sizes, and present a homogeneous, minutely granular, pulpy substance, filled with numerous minute, various-sized, more or less globular, highly refracting particles (Fig. 11). These processes apparently correspond to the analogous folds or nutritive processes, as they are termed, of the *Strongylus* and *Ascaris* (appendices nourriciers of Cloquet).

The cavity of the body thus circumscribed by these lobular folds contains a pultaceous material, in which are imbedded the innume-

rable young, and through it runs a narrow intestinal tube, which extends from the mouth to the caudal extremity of the worm, where it appears to end in a cæcal point. This intestinal tube does not, as in many of the *Nematoidea*, present any division into œsophagus, stomach and intestine, or at all events, the former must be extremely short. It appears to be a simple tube, into which is received probably blood or other fluid from the tissues in which the animal is lodged. Its contents are a brownish, granular material, upon the real nature of which the microscope throws no light. The tube itself is formed of a delicate, transparent membrane (Fig. 13).

Owing either to the coloured substance contained within it, or to the colour of the tube itself, it can readily be distinguished on opening any specimen of the worm in a perfect state. When deficient, it has probably been drawn out, as very readily happens, on account of its loose and unattached condition; for it is not connected with the parietes of the worm, at all events, for the greater part of its length, as the intestine is in most of the *Nematoidea*, by filamentary mesenteric processes. In consequence of this unattached condition it is very readily lost from detached portions of the worm, and it is probably in consequence of some accidental circumstance of this kind that Mr. Owen has been unable to detect any digestive tube after a careful examination of three individuals (Cycloped. Anat., vol. ii. p. 144).

The young *Filariæ*, as I have said, occupy the cavity of the body around this intestinal tube, and are mixed with a pultaceous material, sometimes agglomerated into minute irregular masses. There is no vestige of any ovarian tube, or of any other viscus than that described above: and the only apparent outlet for the young is the open extremity of their parent when making its exit. It would consequently appear that a rupture of the body of the parent is required for the escape of the offspring.

The young of the *Filaria* are amazingly numerous; in most instances constituting the bulk of the contents of the animal's body. But they seem to me to be less crowded towards the caudal end, at which part the pultaceous material in which they are lodged predominates.

The young *Filaria*, when expelled from the body of the parent, is scarcely visible to the naked eye. It consists of a rounded body, constituting about $\frac{3}{5}$ths its length, and of an attenuated tail or caudal extremity constituting the other $\frac{2}{5}$ths. The blunt extremity exhibits a rounded oral orifice, communicating with what appears at first sight

to be a simple ventricular cavity, occupying the whole length of the body or thicker portion, and terminating posteriorly in a blind, pointed extremity, as shown in Fig. 14, *a*, *a*, *a*, but upon closer examination this ventricular cavity is found to be formed of a folded or spiral tube, as shown in Fig. 14, *b*, *b*. The caudal extremity appears to be solid. The external surface is marked with delicate and regular circular rugæ, as in the parent animal. The longitudinal, muscular bands are not evident. The interior usually contains coarse granular matter, much resembling that in which the young *Filariæ* lie, but mixed with many larger, more refractive, globular masses, apparently of an oily nature. Although no muscular fibres are evident under the closest examination, there can be no doubt of the existence of muscular substance in some form or another, as when first extracted the young *Filariæ* are very active. They are also extremely tenacious of life, and will revive after having undergone a considerable degree of desiccation: a fact which accident has enabled me to verify from actual observation.

In a case in which extraction of the worm was going on, the man himself, in pulling at it one evening, broke off a portion about four inches in length, and in order to preserve it to show me on the following morning, he placed it between the leaves of a book. He gave it me in the morning, when it was quite dry and flattened. As I was desirous of examining the structure of the worm, I placed this dried portion in some lukewarm water, in order to soften it, and was surprised a short time afterwards, on proceeding to the examination, to observe the young in active motion, and which continued for some hours. I am unable to assign the limits of this vitality or the conditions necessary to its maintenance for any length of time; but experiments with this object would be highly interesting, though it appears probable that they would require for their complete success to be undertaken in the countries where the worm is endemic. The young, when fully formed, do not appear to be attached in any way to the parent animal, and they are nearly always of a uniform size, and consequently may be supposed to be of the same age, and I have not observed any differences in this respect in the successive portions of the parent worm as they have been brought away. But there is nothing to disprove the supposition that the young lodged in the posterior part of the body of the parent may be undergoing progressive development, whilst their companions are being slowly issued into the world at the other extremity. I have occasionally, though very rarely, met with instances of imperfectly formed young ones, one of

which is represented in Fig. 14, *e*, which will be observed to differ very much from the more fully developed ones shown in Fig. 14, *a*, *a*, *a*, and principally in the absence of the attenuated caudal extremity. There are also sometimes to be observed in the pulpy substance of the parietes of the worm, elongated, oval bodies, of a granular structure, and firmly attached to the membrane, and which may perhaps represent a still earlier stage of the embryo's growth, but this is as yet very uncertain (Fig. 12). In the instance of the worm now on the table, and which may be considered as approaching the term of its latent condition, the young already correspond with the description given above, and appear to be alike in all portions of the worm.

Having thus briefly described the chief points connected with the anatomy of the worm, I will proceed with a few observations as to its presumable nature. The now rather numerous facts that have been collected with reference to the occurrence of an alternation of generations in many of the lower classes of animals, or it may almost be said, in all the Invertebrata, in some mode or another, already afford considerable ground for the support of an hypothesis which will serve to throw considerable light upon the hitherto obscure relations that obtain in many of the multiform creatures thrown together under the name of *Entozoa*.

In a recent work by a Danish naturalist, Steenstrup, published by the Ray Society, a tolerably complete exposition will be found of all that is yet known on this interesting subject. The longest and most complete chapter of that work refers to the *Entozoa*, but principally to the Trematode class, to which the author's own observations were especially directed. The development of distomata of more than one species is there, satisfactorily to my mind, deduced from *Cercariæ*, which live in water external to the animals which they afterwards infest. The mode in which these parasites penetrate the water-snails is clearly detailed, and reference is made to other observations tending to prove, that a penetration from without in earlier stages of development of the parasites is not confined to those soft-skinned animals alone, but takes place in fish, and even through the intestinal canal of Batrachians. Having thus proved the penetration from without and the existence of alternate generations, presenting entirely different forms, in the Trematode class, the probable existence of a similar alternation of generations in the *Nematoidea* is alluded to, and the instance of one (*Sphærularia*), a parasite of Hymenopterous insects, is adduced as an instance of the kind. Though the supposi-

tion is probably incorrect in this instance, as the nematoid worm above mentioned has been found by Eschricht to possess sexual organs, the *Filaria medinensis*, in my opinion, does present an instance of a transition form of the nature alluded to. It must be confessed, however, that as yet the existence of an anterior and succeeding form to that with which we are acquainted in the Guinea worm, rests only upon circumstantial evidence. The intermediate form in all those animals in which the mode of development by means of alternate generations obtains, or as it is termed by Steenstrup, the "nursing" generation, though of various kinds in other respects, presents in all cases certain common distinctive characters.

1. It is always female in its attributes.

2. The modification which the female organism undergoes for the purpose of becoming a "nurse," at all events, when destined for that class of "nurses" in which the third or fourth generation, as the case may be, is to be developed, consists in the abortion of parts of the generative tube, viz., the ovaries and oviducts. "Nurses" of this kind may, in fact, as Steenstrup says, be considered as individualized "uteri."

3. It is always proligerous, never oviparous.

Now if we consider the anatomical structure and the external relations of the Guinea worm with reference to the above particulars, we shall find that it presents all the characters of a "nursing" or intermediate generation.

1. It is unisexual and female.

2. The female organs are modified, so that no trace of an ovary or of anything but what may be considered a uterine cavity remains.

3. It is also necessarily only proligerous.

The truth of the first proposition of course depends upon the certainty of there being no male *Filaria medinensis*, as I have before observed. The second and third propositions are sufficiently obvious, and in fact are so obvious that M. Jacobson compares the body of the worm to a tube or sheath inhabited by the young ones, than which, a more accurate definition of one of Steenstrup's "nurses" could scarcely be given.

We are, however, still deficient in any knowledge of some very important points connected with this worm, and which it is necessary should be determined before the theoretical view of its nature I have ventured to propose can be deemed anything more than an uncertain speculation.

But a strong proof in favour of the opinion that the Guinea worm

enjoys in some form or other an existence external to the bodies of animals, is derived, as I think, from the circumstance already mentioned as having been observed with respect to its limited local distribution, even in those regions where it is endemic. It has been stated by various writers, and I have had the observation confirmed by men who had been on the coast of Africa, that the prevalence of the Guinea worm is sometimes defined by a distance of a few leagues. That in one part, for instance, of the coast, almost every inhabitant will be found affected with it, whilst at another, only a few leagues off, the worm will be almost unknown, notwithstanding there being no restriction upon the intercourse between the inhabitants of the one part with those of the other. It may also be observed that the Guinea worm is never found to spread from one person to another in any other parts of the world than those indicated above, or as it may be said, where it is indigenous, even allowing that the contagion is direct from person to person, even there. The island of Curaçoa affords, as has been already mentioned, the only doubtful exception to this position.

Now I think that consideration of these facts will lead to the probable supposition that the worm requires, in some stage of its existence, a certain condition of external nature for its propagation and development. For it is evident that during its latent stage it must be, to a great extent, independent of external influences, and will arrive at maturity *as a parasite* under the most various conditions of climate and race in the person affected with it.

The conclusions, then, to which I am inclined to come from what is known respecting the Guinea worm, are:—

1. That the parasitic condition is one phase or stage of its life, not as an individual, but as a species.

2. That this parasitic form is preceded and followed by other forms, in one of which the species exhibits itself in its complete development, and is probably like other worms of the nematoid class —bisexual; and that the young found within the parasitic form represent probably these complete individuals in the embryo state.

3. That these embryos arrive at their full development externally to the animal economy, and require for their development conditions of external nature which appear to occur only in some parts of the globe.

4. That the perfect form of the *Filaria medinensis* is at present unknown, and is to be sought for, in all probability, only in those countries where the worm is endemic as a parasite.

DESCRIPTION OF PLATES X AND XI.

Figs. 1—4. Exhibit the varieties presented by the caudal extremity of the Guinea worm (all proligerous).

Fig. 5. Shows obscurely the termination of the intestinal tube, towards the caudal extremity of the worm.

Fig. 6. The integument of the worm laid open, and exhibiting a portion of the longitudinal band of muscle on one side, much retracted (*a*), and on each side of it a narrow tract of granular substance, with a (supposed) central canal (*b*, *b*). N.B. It is not improbable that these lateral tracts are connected by a thin expansion lying on the internal aspect of the muscular band.

Fig. 7. A portion of the muscular band more highly magnified.

Fig. 8. Transverse section of part of the cylinder of the worm.
a. The external integument.

Fig. 9. A view from the interior of a similar portion.

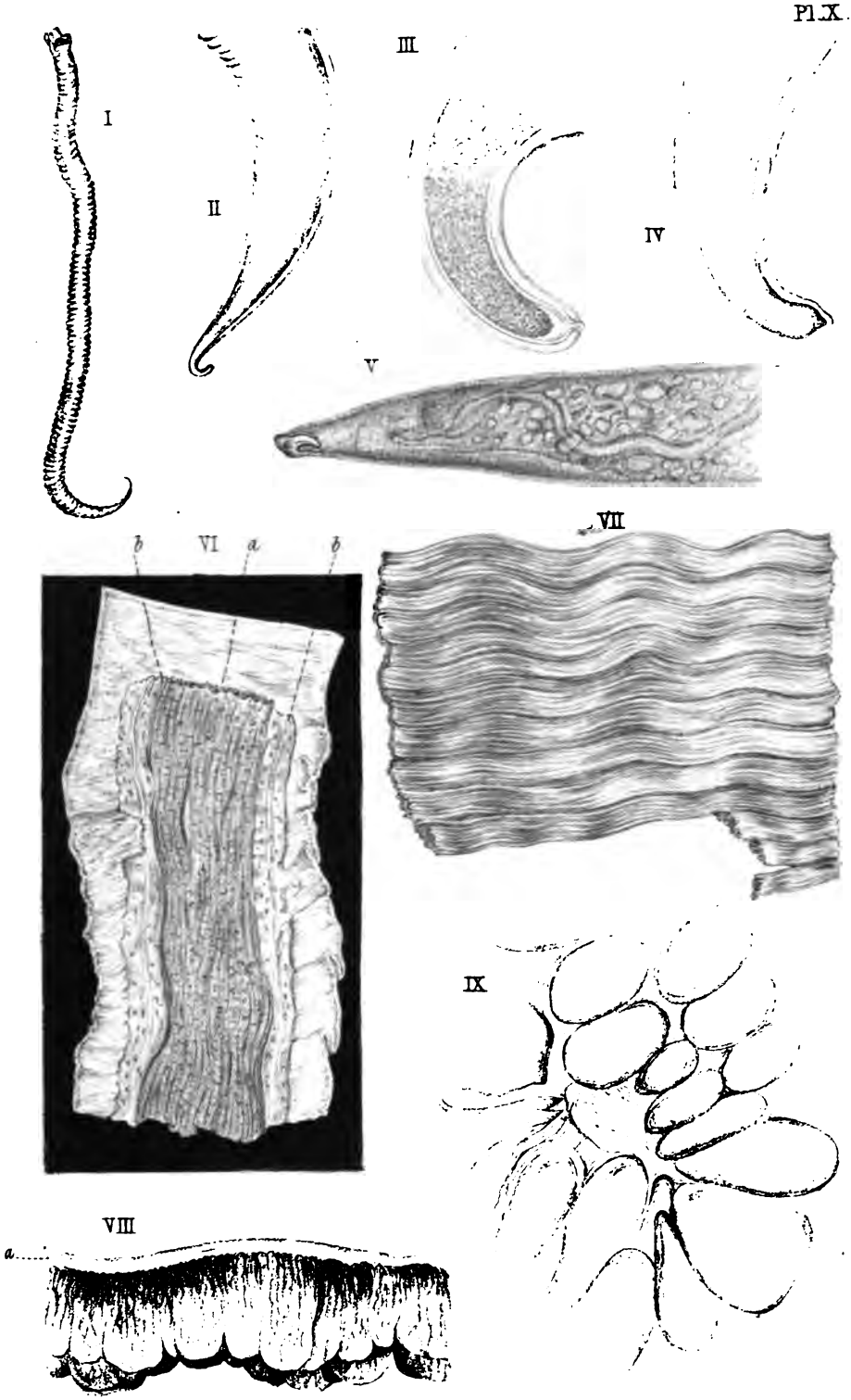
Figs. 10, 11. Exhibit the appearance of the membrane constituting the folds of the internal tube.

Fig. 12. Oval granular bodies, scattered here and there on the inner surface of the integument, or between the two tubes of which the body of the worm is constituted.

Fig. 13. A portion of the intestinal tube, composed of a delicate, transparent membrane, with its brownish, granular contents (no epithelium observable).

Fig. 14. *a*, *a*, *a*, Young *Filariæ*. *b*, *b*. The convoluted form assumed by the internal tube of the young *Filariæ*, when macerated in water and partially decomposed. *c*. A long *Filaria*, rolled up, and not quite so large as the straight ones. *d*. The more highly magnified caudal extremity of a young *Filaria*. *e*. A form of young *Filaria*, occasionally, though very rarely observed.

Pl. X.



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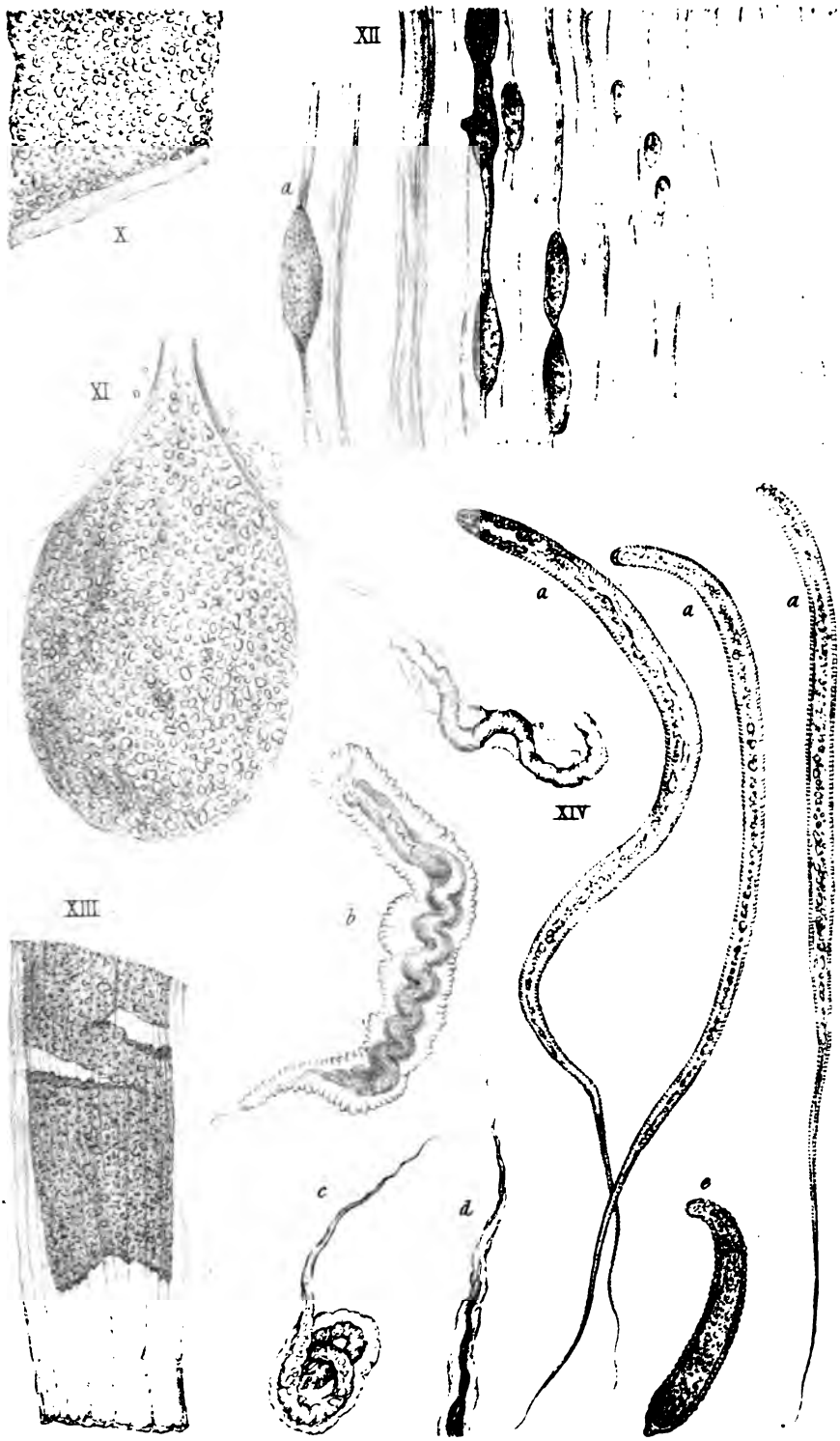

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XII.—*On the Occurrence of Fossil Xanthidia and Polythalamia in Chalk.* By Henry Deane, Esq.

(Read October 15, 1845).

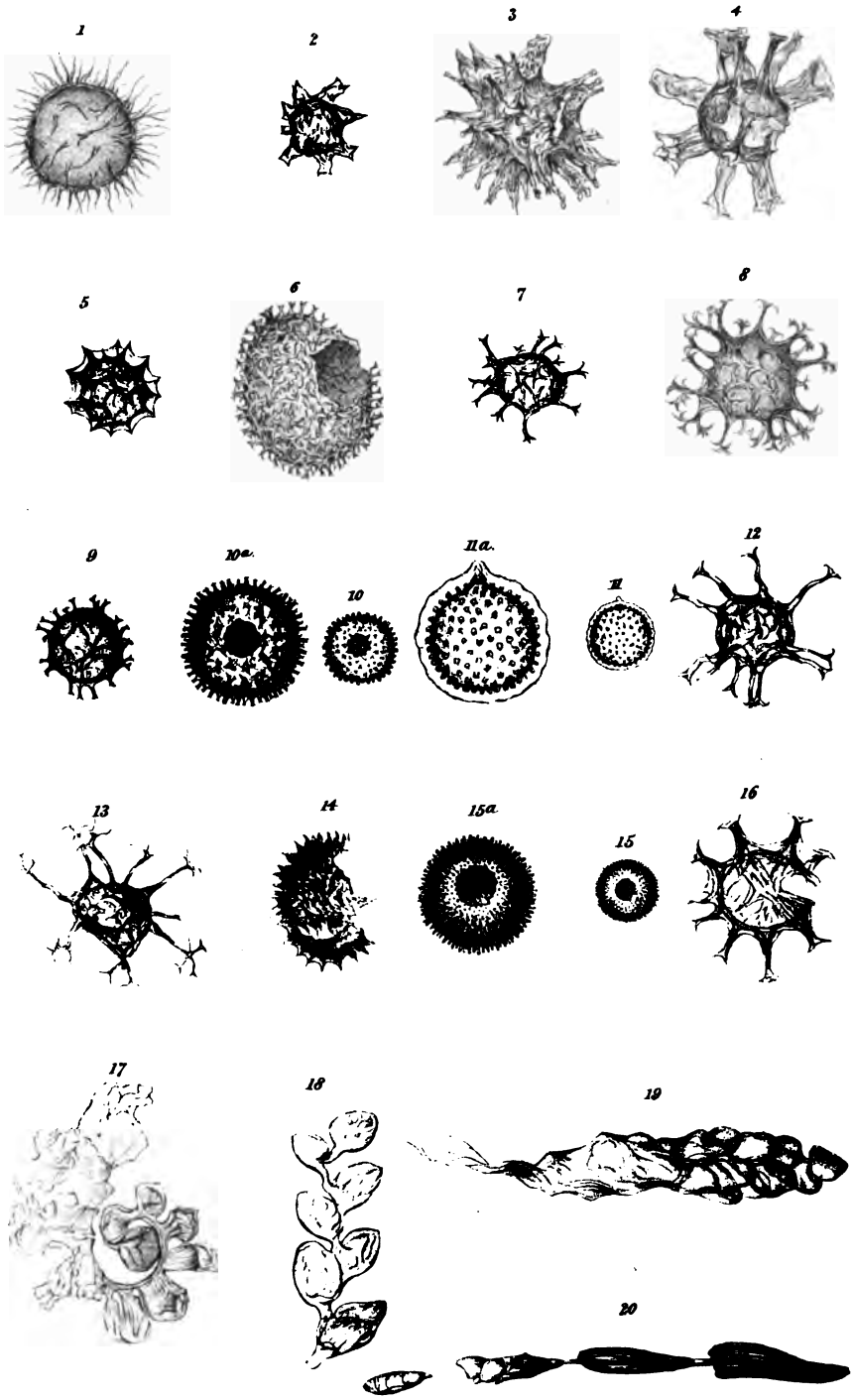
The occurrence of *Xanthidia* in either a recent or fossil state, has not hitherto been observed in any other situation than in flint nodules of the upper chalk formation, and it has been a matter of surprise that the chalk itself surrounding the flints should not have afforded evidence of their existence. So perfectly free from them does it appear, that the prevailing opinion has been, they had not an existence out of the flints themselves, that is to say, floating loosely as independent beings in the seas of the cretaceous period; but that they were immediately connected with the substance, whether animal, vegetable, or spongeous, which, in the course of decomposition, has been replaced by the silica, now forming the nodules in which they are found. My own observations had led me to the conclusion that they were independent animal existences,—whether of sponges or not I could not tell,—and in all probability to be found elsewhere than in flints. These views have lately been remarkably confirmed by my finding them abundantly in a piece of chalk, picked up in the course of a ramble along the beach between Folkstone and Dover. Proceeding along the beach from Folkstone towards Dover, and at a short distance before arriving at Lydden Spout and the ruins of Round Down Cliff, a grayish kind of chalk, having no flint nodules, so far as I could find, but containing quantities of nodules of iron pyrites, juts into the sea, and forms the beach for some distance. Many of these pyrites had the shape of shells which had formed their nuclei, and one piece contained something like charred wood. The appearance of fossils so remarkably different from those in the bed of chalk immediately above them, led me to conclude that there might be other organic remains of an interesting nature, for microscopic examination. I therefore cut out a piece of pyrites of singular form, with the adherent chalk, and afterwards dissolved it out by means of hydrochloric acid. The copious insoluble sediment left after the action of the acid, being examined by the microscope, exposed to view bodies similar to, if not identical with, the *Xanthidia* in flints; and I could clearly recognize *X. spinosum, ramosum, tubiferum simplex, tubiferum recurvum, mal-*

leoferum, and *pyxidiculum*, together with casts of *Polythalamia* and other bodies frequently found in flints.

This singular discovery at once suggested the possibility of ascertaining the true nature of these bodies, as it afforded facility for isolating and mounting them in various ways for examination. From their minuteness, however, it was impossible to examine them chemically, or to apply a powerful solvent without risk of damaging the instrument, while observing its effects upon them. In shape they are somewhat flattened spheres, the greater part of them having a remarkable resemblance to some gemmules of sponge, and having a circular opening in the centre of one of the flattened sides (Plate IX. figs. 10 and 11). The arms or spines of all appear to be perfectly closed at the ends, even including those which have been considered in the flint specimens to be decidedly tubiferous, showing that if the arms are tubes they could afford no egress to a ciliated apparatus, similar to those existing among zoophytes. On submitting them to pressure in water between two pieces of glass, they were torn asunder laterally like a horny or tough cartilaginous substance, and the arms in immediate contact with the glass were bent. Some specimens put up after several weeks maceration in water, were so flaccid that, as the water in which they were suspended evaporated away, the spines or arms fell inclined to the glass. These circumstances alone seem clearly to disprove the idea of their being purely siliceous. The casts of the *Polythalamia*, portions of minute crustaceans &c., appeared also to be, like the *Xanthidia*, some modification of organic matter, and in the case of the *Polythalamia*, the bodies are so perfectly preserved, that in some the lining membranes of the shells are readily distinguished (figs. 17—19). By far the greater number of the specimens of *Xanthidia* found in flints, are more or less mutilated and crippled; and it is not a little remarkable that the same state, both as to character and extent of deformity, exists among those in the chalk, and affords strong presumptive evidence of the identity of the two objects. During the investigation I had observed many thin, empty shells, somewhat like the husks of peas, more transparent than the *Xanthidia*, somewhat crumpled, and, with one exception, cracked open laterally. The entire one contained a small globular body, about the size and color of the smallest kind of *Xanthidia*, but quite smooth.* These I conceived to be identical with the *Pyxidicula* of the flints. This fact seems to throw a little light on their nature, and taken with the circumstance that a large

* I have since found reason to believe many of these bodies to be portions of *Rotaliæ*.

Pl. IX.



Lens Aldous del. et Lith.

Day & Son, Lith.rs to the Queen.

portion of the disengaged bodies, varying in the roughness of their surfaces, bear a strong resemblance to the gemmules of some sponges, which are of course known to be the rudimentary sponge, has led me to the belief that they also are but rudimentary forms of some animal or animals in a progressive state of developement, and that whatever connexion they may have had with the matter once occupying the place of the flint, they certainly appear to have no natural connection with *Xanthidia*, so called, of our freshwater ponds.

EXPLANATION OF PLATE IX.

Figs. 1 to 16.	Various forms of Xanthidia, magnified		260	linear.
Figs. 10 *a*, 11 *a*, 15 *a*.	Ditto,	„	460	„
Fig. 17.	Three Polythalamia,	„	260	„
Fig. 18.		„	260	„
Fig. 19.		„	460	„
Fig. 20.	A minute coralline (?)	„	140	„

XIII.—*On a Mode of Isolating the Siliceous Shells of Infusorial Animals found in Ichaboe Guano.* By H. Deane, Esq.

(Read October 15, 1845.)

Soon after the guano from Ichaboe reached this country, it was found to contain the siliceous shells of infusorial (?) microscopic animals, allied to those brought from Richmond, in Virginia, and from Bermuda. But the patient searching of many of my friends, was only rewarded by the occasional appearance of a solitary *Coscinodiscus*, or something analogous, until it occurred to me to decompose the guano with nitric acid. The result was very satisfactory; and the following is the process I adopted.

Take any convenient quantity of pure Ichaboe guano, and wash it by repeated ablutions of distilled water, until the water is no longer coloured, observing after each addition of water, that it must be well stirred two or three times, and then allowed to settle for some hours. When sufficiently washed, a small quantity of hydrochloric acid is to be added to the water last used: this dissolves some portion of it with effervescence, and causes a more perfect subsidence of that which it does not act upon. After this, allow sufficient time for the deposit to become well settled down; then, the clear liquor being poured off as closely as possible without loss of the sediment, a quantity of strong nitric acid, in the proportion of about two fluid ounces to every ounce by weight of guano employed, is to be added. A strong effervescence ensues, which is to be assisted by setting the mixture in a warm place, at the temperature of about 200°, for six hours, during which time, the greater part of the guano is dissolved. After allowing it to cool for twenty-four hours, pour off the acid liquor as closely as possible, and wash the sediment with an abundance of distilled water. The finer portions of this sediment will contain all the siliceous shells of the guano, perfectly freed from extraneous matter. The accompanying slide, for the museum of the society, was prepared in the manner just described, and contains many very beautiful species, most of them well known, but many new both to myself and others more experienced in this branch of microscopic observation.

XIV.—*A New Application of Polarized Light in examining every description of Objects.* By JOHN KING, Esq.

(Read November 11, 1846).

TAKE for an analyzer a double-image prism, of moderate separating power, and place it over the eye-piece of the instrument.

The field will then appear to be edged by two areas of less intensity than the centre, occasioned by the duplication of the circle of light.

Next put upon the stage a plate of selenite, which exhibits, under ordinary circumstances, the red ray in one position of the polarizing prism, and the green ray in another, and each arc will assume one of these complementary colours, whilst the centre of the field will remain perfectly colourless.

Into this field introduce any microscopic object; and, whatever its structure, it will exhibit the effects of polarized light, with great intensity and purity of colour.

In this way, many objects which, in the usual arrangement of the polariscope, undergo no change in colour, are made to display the most brilliant effects.

Sections of wood, feathers, *Algæ* and scales, are among the objects best adapted to this kind of exhibition.

By substituting selenite that shows a variety of colours, the effects are still more gorgeous.

The best power for the purpose is a two-inch object-glass, the intensity of colour as well as the separating power of the prism being impaired under much higher amplification, although in some few instances, such as in viewing animalculæ, the inch object-glass is, perhaps, to be preferred.

The following appears to afford an explanation of this remarkable fact; but diffident of my own opinion, I respectfully submit it to the notice of those members of the society who have made the subject of polarized light their study.

This phenomenon is attributable to the double-image prism separating the constituents of the polarized ray into two planes, and causing them to overlap each other, except at the edges where the light is analyzed; and, of course, the combination of the complementary colours

in the centre of the field, produces again white light. Any object, therefore, placed in the white field, partakes of the characteristics of the selenite; one image being refracted into the plane which exhibits the green ray, assumes that colour, whilst the second image being refracted into the plane of the red ray, partakes of that tint. Should, however, the object be so large that actual separation of the images is not effected, the extremities and interstices only will be polarized, whilst the middle will remain dark, or present only its natural hue.

XV.—*On the Application of Polarized Light in Microscopic Investigations.* By M. S. Legg, Esq.

(Read December 9, 1846).

It has been truly and eloquently observed by Sir David Brewster, that "the application of the principles of double refraction to the examination of structures is pregnant with a very high interest. The chemist may perform the most dexterous analyses; the crystallographer may examine crystals by the nicest determination of their forms and cleavages; the anatomist and the botanist may direct the dissecting-knife and use the microscope with the most exquisite skill; but there are still structures in the mineral, the vegetable, and the animal kingdoms, which defy all such methods of examination, and which will yield only to the magical analysis of polarized light. A body which is quite transparent to the eye, and which appears upon examination to be as monotonous in its structure as in its aspect, will yet exhibit under polarized light the most exquisite organization, and will display the result of new laws of combination, which the imagination even could scarcely have conceived. Like the traveller who has visited an unknown land, polarized light emerges from bodies bearing with it the information it has acquired during its passage, and indicating the structures through which it has passed, when put to the question of optical analysis. As an example of the utility of this agent in exploring mineral, vegetable, and animal structures, I may refer to the extraordinary organization of Apophyllite and Analcime; the symmetrical and figurate depositions of siliceous crystals in the epidermis of Equisetaceous plants; and to the wonderful variations of density in the crystalline lenses and the integuments of the eyes of animals." *

In order, therefore, to facilitate the application of this principle, and to render the subject interesting to those who may be disposed to adopt it in microscopic investigation, or who may already have the necessary apparatus fitted to their instruments, as well as for the information of those whose avocations may have debarred them from the study of this branch of natural philosophy, it is proposed to describe a series of apparatus, and to detail some experiments which, although well known to a few, are not generally understood by mere microscopic

* Report on Optics, Brit. Ass. 1832.

observers, and which may generally be adapted to almost any instrument.

In conducting experiments on this subject it is usual to employ one of three methods of producing polarized light, viz.—

1st. *A bundle of plates of crown glass* (see Pl. XII. fig. 1), from which the light is to be reflected at an angle of 56° from the perpendicular, a portion of the light being reflected from the surfaces of the glass, and another portion being transmitted, each of these portions is found by analysis to consist of rays of light polarized in opposite planes. This method is employed when it is required to illuminate a large object, as in the single or doublet microscope, and in the oxy-hydrogen apparatus.

2nd. *A plate of tourmaline* (see fig. 2), cut parallel to the crystalline axis of the crystal: it is necessary to be careful in the selection of tourmalines; they should be as free from colour as possible, and dark-coloured ones to be avoided as almost useless in investigations of colours. Tourmalines are, however, seldom used as polarizers, in consequence of the difficulty of obtaining them of sufficient magnitude.

3rd. *A Nicol's or single-image prism* (see fig. 3), which is a portion of a crystal of Iceland spar cut and combined with a piece of glass, so as to throw out of the field of view one of the two images produced by the double refraction of the crystal. This is the most eligible for the compound microscope, in being perfectly free from colour, and requiring no adjustment beyond transmitting the light, either direct or reflected from the mirror; it may be fitted into the diaphragm, and also be adapted to the achromatic condenser, to be employed with high powers in the examination of minute structures.

As a test of polarized light, it is necessary to employ analyzers of the most convenient form; they consist of apparatus possessing the same properties as the polarizers, that is, of causing light to pass in only one plane of vibration: the polarizer and analyzer should, when superposed, allow the light to pass freely in one position, and produce a dark field when turned one-fourth of a revolution; for this purpose either of the two last-named pieces of apparatus can be employed: the tourmaline will be found useful for ascertaining if the object under examination possess the property of polarization, as it may be placed over the eye-piece without cutting off any part of the field of view; but if the analyzer be required as a test of colour, the Nicol's prism should be employed, and placed in the body of the instrument, and as near to the back of the object-glass as possible.

The following experiments, if carefully performed, will illustrate the most striking phenomena of double refraction, and form an useful introduction to the practical application of this principle.

The apparatus necessary is—

A Nicol's prism to be adapted under the stage;

A double refractor adapted to the eye-pieces;

A film of selenite, of uniform thickness, adapted according to its crystalline axis; and

A plate of brass, 3 inches by 1, perforated with a series of holes, from about the $\frac{1}{16}$th to $\frac{1}{4}$th of an inch in diameter: the diameter of the smallest hole should be regulated according to the power of the object-glass and the separating property of the double refractor.

Exp. 1. Place the piece of brass so as for the smallest hole to be in the centre of the stage of the instrument, employing a low power (about $1\frac{1}{4}$ inch) object-glass, and adjust the focus as for an ordinary microscopic object; place the doubly-refracting crystal over the eye-piece, and there will appear two distinct images; then by revolving the eye-piece the images will describe a circle, the circumference of which cuts the centre of the field of view; the one is called the ordinary, and the other the extraordinary ray. By passing the slide along, so as for the larger orifices to appear in the field, the images will not be completely separated, but will overlap as in fig. 4.

Exp. 2. Screw the Nicol's prism into its place under the stage, still retaining the double refractor over the eye-piece; then by examining the object there will appear in some positions two, but in others only one image; and it will be observed that at 90° from the latter position this ray will be cut off, and that which was first observed will become visible; at 180°, or one half of the circle, an alternate change will take place; at 270° another change; and at 360°, or the completion of the circle, the original appearance (see fig. 6).

Before proceeding to the next experiment, it will be as well to observe the position of the Nicol's prism, which should be adjusted with its angles parallel to the square parts of the stage (see fig. 10), in order to secure the greatest brilliancy in the experiment: the proper relative position of the selenite may be determined by noticing the natural fractures or flaws in the film, which will be observed to run parallel to one another: these flaws should be adjusted at about 45° from the square parts of the stage (see fig. 11) to obtain the greatest amount of depolarization.

Exp. 3. If we now take the plate of selenite thus prepared, and place it under the piece of brass on the stage, we shall see, instead of the alternate black and white images, two coloured images (as in fig. 7), composed of the constituents of white light, which will alternately change (by revolving the eye-piece) at every quarter of the circle; then by passing the brass along, so as to bring the larger orifices in succession into the field, the images will overlap, and where they overlap white light will be produced (see fig. 5). If by accident the prism should be placed at 45° from the position just indicated (see fig. 12), no particular colour will be observed, and it will then illustrate the phenomenon of the neutral axis of the selenite, because when placed in that relative position no depolarization takes place.

The phenomena of polarized light may be farther illustrated by the addition of a second double-refractor, and a film of selenite adapted between the double-refractors.

Exp. 4. By placing the apparatus as described in the first experiment (that is, removing the Nicol's prism and plate of selenite, but retaining the brass plate), we shall observe the two images as shown in fig. 4; then by placing the second double-refractor over the first, so as for all the faces of the one to be parallel to all the faces of the other, as if they formed but one piece, the eye will perceive two distinct images, but at twice the original distance from each other (see fig. 8). If we now turn the crystal nearest the eye, from left to right, two faint images will appear; continuing the turn, the four images will be all equally luminous; and when the crystal has turned round 90°, there will be only two images of equal brightness. Continuing the turn, other two faint images will appear; further on the four images will be equal; still further they will be unequal; and at 180° of revolution they will all coalesce into one bright image.

Exp. 5. The above results will be rendered more interesting by interposing between the doubly-refracting crystals the film of selenite. Place the doubly-refracting crystals and the selenite upon the brass mountings, so that the marks upon the brass mountings (as in figs. 13, 14 and 15) shall correspond. Instead of the two white images, as in the preceding experiment, we shall see three, of which the two outer ones will be one colour (say green), and the middle its complementary colour or red; by turning the crystal nearest the eye, the middle image will gradually divide, until the completion of a quarter revolution, when four images will appear, of equal brilliancy, two of each colour; revolve the crystal until the completion of the half circle, and the three images will reappear, but with different properties, the outer

images being red and the middle green; at another quarter revolution, four images, but with opposite colours, will be observed, and at the completion of the revolution the original appearance (see fig. 9).

If instead of the relative positions of the crystals and selenite, as indicated in this experiment, the positions be changed, so that the selenite shall be at 45° from its former position, the ventral axis of the selenite will be parallel or perpendicular to the plane of polarization, and as in that position no depolarization takes place no colours will be produced, and the results will appear as if no selenite were interposed.

The systems of coloured rings, in crystals cut perpendicularly to the principal axis of the crystal, are best seen by screwing the Nicol's prism under the stage and employing the lowest object-glass; place the crystal over the eye-piece, and use either a short prism or a tourmaline as an analyzer.

The above remarks are submitted to the notice of the Microscopical Society in the hope of directing the attention of scientific observers to this branch of optical science, in which so much scope still exists for the determination of the laws of various phenomena in natural history. According to the opinion of the eminent author first quoted, "There is scarcely any branch of the subjects of double refraction and polarization which does not afford the richest fields of discovery. Even the theory of undulations, with all its power and all its beauty, is still burdened with difficulties, and cannot claim our implicit assent. It has not yet brought under its dominion the phenomena of elliptic polarization in all its varieties, from the rectilineal polarization of transparent bodies to the almost circular polarization of pure silver. It has not yet explained the singular influence of the force of double refraction over the force which polarizes light, and it has great difficulties to struggle with in accounting for certain phenomena of absorption.

"The determination of the physical data of these departments of science constitutes a new and almost untrodden field, which may be successfully cultivated by almost every variety of talent. The refractive indices of the two pencils in all crystallized bodies, measured in reference to fixed points of the spectrum, as has been lately done by Rudberg; the angles at which light is polarized by reflexion from crystallized and uncrystallized surfaces; the inclination of the resultant axes of crystals having double refraction, for different rays of the spectrum; the dimensions of the ellipse which regulates the polarization of metals and their alloys; the circularly polarizing forces

of fluids and solutions; and the refractive and dispersive powers of ordinary solid and fluid bodies, measured according to the method of Fraunhofer,—are some of the points to which we would call the attention of young and active observers."

EXPLANATION OF PLATE XII.

Fig. 1 represents a bundle of plates of crown glass, in which a ray of common light, having two or more planes of vibration, is reflected at an angle of 56° from the perpendicular, the portion which is reflected having one plane of vibration, and that which is transmitted vibrating in a plane at right angles to it.

Fig. 2. A plate of tourmaline: the light which emerges after transmission is found to consist of polarized light, vibrating in a plane corresponding to the axis of the crystal.

Fig. 3. A Nicol's prism: a ray of light, on entering the prism, is divided into two pencils, one of which is transmitted, and the other is so refracted, by means of the glass, that it is thrown out of the field.

In these figures, the arrows indicate the direction of the ray of light; the circles with crossed lines represent common light; and those with only one line polarized light, with its plane of vibration.

Fig. 4 represents the complete separation of the images by the double-refractor, and the effect of passing the larger orifices of the brass plate along the stage.

Fig. 5 shows the effect of adding a Nicol's prism and plate of selenite, with the decomposition and recomposition of white light.

Fig. 6 gives the appearance of revolving the double-refractor, and the alternate cutting off of each image, at every quarter of a revolution (as in Exp. 2).

Fig. 7. The same as before, with the addition of a plate of selenite.

Fig. 8. The effects produced by two double-refractors, in separating the images to twice the distance from each other, compared with those in fig. 4, and the appearances presented at every quarter revolution of the second crystal.

Fig. 9. The same as above, with the interposition of the plate of selenite.

Fig. 10. The most suitable position for the Nicol's prism in investigations where a plate of selenite is employed.

Fig. 11. The proper position of the selenite, in relation to the polarizer, to produce the best effects.

Fig. 12. The Nicol's prism, turned about 45° from its former position, which should be carefully avoided in using the selenite plate.

Figs. 13, 14 and 15. The brass mountings of the double-refractors and plate of selenite. The crystals and selenite should be adjusted to the relative positions indicated in figs. 10 and 11, and the slits in the mounting placed in a line, to produce the appearances in fig. 9.

M.S. Legg, del. — Lens Aldous, Zinc

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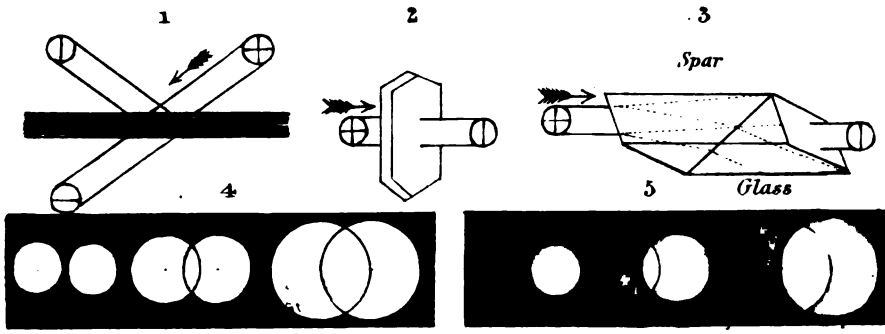
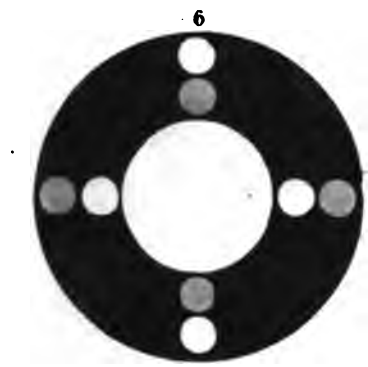
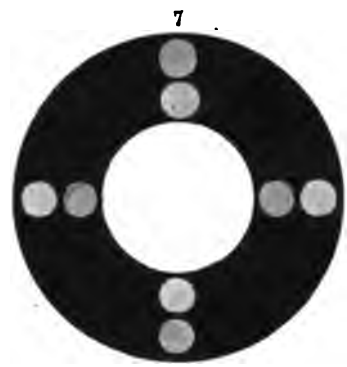
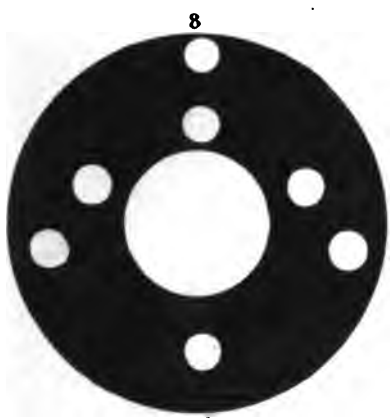
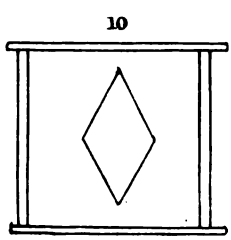
Plate XII.

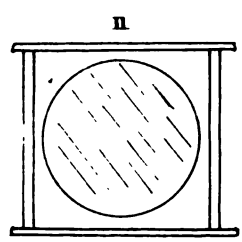


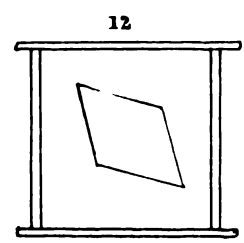


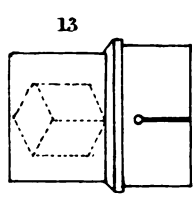


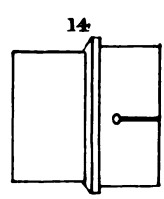


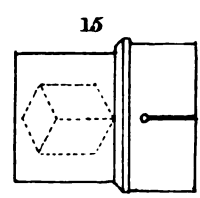












M.S. Legg del. Lens Aldous Zinc

Day & Son, Lith^rs to the Queen.

XVI.—*Observations on Xanthidium, both Fossil and Recent.* By SAMUEL JAMES WILKINSON, Esq.

(Read January 14, 1846).

THE interesting genus *Xanthidium* among the fossil *Infusoria* is so well known to microscopists that it is quite needless for me to enter upon an explanation of its peculiarities. My object is to bring under notice two peculiar forms of *Xanthidium* which I have lately met with in some slides prepared from gun-flints, and which differ from any of the figures accompanying Mr. H. H. White's paper on this subject (see Vol. i. p. 77),—one in particular, as at Plate XIII. figure 1, where it will be perceived that the tentacula, instead of diminishing in diameter from the base towards the apex, gradually dilate in that direction, a difference so remarkable that there can be no doubt of its being a distinct species. Unfortunately, I am unable to state that more than one specimen has come under my observation, and that one has the disadvantage of being imperfect. Figure 1 represents it as it appears under the microscope, but there is a sufficient portion of it to form a very correct idea of its perfect form, of which the following may be taken as the characters.

Body ovate, hollow, with tubiform tentacula, smallest at the base, and gradually dilating to the apex, having their terminations depressed and irregularly stellate.

The body is smaller than in other fossil species when compared with the tentacula, which latter are nearly equal to two diameters of the former, and if the specimen were entire they would amount to from twelve to fifteen in number. The size of this species is about $\frac{1}{250}$th of an inch in diameter, and I beg leave to distinguish it under the name of *Xanthidium claviferum** from the nail-like form of the tentacula.

The other fossil species, as represented in Pl. XIII. fig. 2, is likewise in a portion of a gun-flint, but I do not think there is sufficient difference between it and Mr. H. H. White's figure 5 of Pl. VIII. Vol. i., which he calls *Xanthidium spinosum*, to designate it as new, and

* This species was originally named *Xanthidium tubiferum dilatatum*, but as the duplex trivial name is contrary to the rules of nomenclature, it has been thought advisable to alter it to *Xanthidium claviferum*, which is perhaps more expressive of the character of the tentacula.

I have, therefore, merely drawn it to represent a peculiarity which I have never met with in that or any other species. On reference to the figure, there appears, as it were, a groove or division round the circumference, similar to that formed by two cups when placed on each other so as to make their rims or upper edges meet. There also seems to be a peculiarity in the arrangement of the tentacula:—the tentacula of *Xanthidia* generally pass from the body in a direction perpendicular to its centre without any apparent fixed arrangement of position, but in this instance an inspection of the figure will show that both in the upper and lower portions there are two circlets of tentacula, one placed round each extremity and another round that part where the specimen appears to be separated. The size is $\frac{1}{325}$th of an inch in diameter; number of tentacula about 25.

I now beg to call your attention to the following observations upon recent *Xanthidia*, and this is I believe the only instance which has been mentioned since Mr. White read his paper in February, 1842, where he states that fig. 14, Pl. VIII. Vol. i. of these Transactions, was a representation of a *Xanthidium* which was received from New York in some water sent to Mr. E. J. Quekett, by Professor Baily, but as I had not the pleasure to see more than the specimen figured by Mr. White, I have taken drawings of the several species which have been brought under my observation by my friend Mr. J. T. Norman. They were discovered in some Thames mud, taken up at Greenhithe, in Kent, in July last: it consisted partly of the usual detritus of the river, and a portion of that slimy description which is found upon piles or stones which are covered by the water at certain states of the tide. After this mud had been washed in the usual manner, the residuum was treated with nitric and sulphuric acids and again washed. These *Xanthidia* are evidently not of a siliceous nature, and it is therefore remarkable that such powerful acids should not have destroyed them. On referring to Mr. Deane's paper on those *Xanthidia* which he found in chalk near Dover, I perceive he also states that *they* are not siliceous. I consider them to be of a horny nature, similar to the wiry-sponges, which Mr. Bowerbank describes as being very dffiicult to destroy without the action of fire.

These recent specimens I have arranged in the same order as laid down in Mr. White's paper, but refrain, in the present state of my enquiries, to assert that they are either new or identical with the fossil specimens figured by him.

I deem the discovery of these species so near to London a very fortunate circumstance, as it will afford opportunity to those persons

who are interested in the subject to follow up these observations, and I look forward to some valuable facts being elicited respecting the economy of the genus.

My endeavours to trace them in Thames mud from other localities much higher up the river, have been entirely without success, but I think this may be attributable to *Xanthidium* being more a marine, than a fluviatile, genus, which opinion is strengthened by the circumstance of their being found at New York, in the Mediterranean, and in our own river approximating to the ocean. I shall, however, continue the enquiry, and if anything worthy of note should present itself to my notice, I shall feel great pleasure in submitting it to the Society.

7, Jeffreys Square,
January 14, 1846.

EXPLANATION OF PLATE XIII.

Fig. 1. Represents *Xanthidium claviferum*, discovered in a gun-flint: it has a hollow oval body, with the tentacula gradually dilating from the base towards the apex, where they terminate in irregularly stellated processes; the tentacula longer than the diameter of the body, and about twelve to fifteen in number. Size $\frac{1}{250}$th of an inch in diameter.

Fig. 2. Found also in a gun-flint. Similar to *Xanthidium spinosum*, but bears a depressed line or division round the body. Size $\frac{1}{312}$th of an inch in diameter; the tentacula terminate in an acute point, and amount to about twenty-five in number.

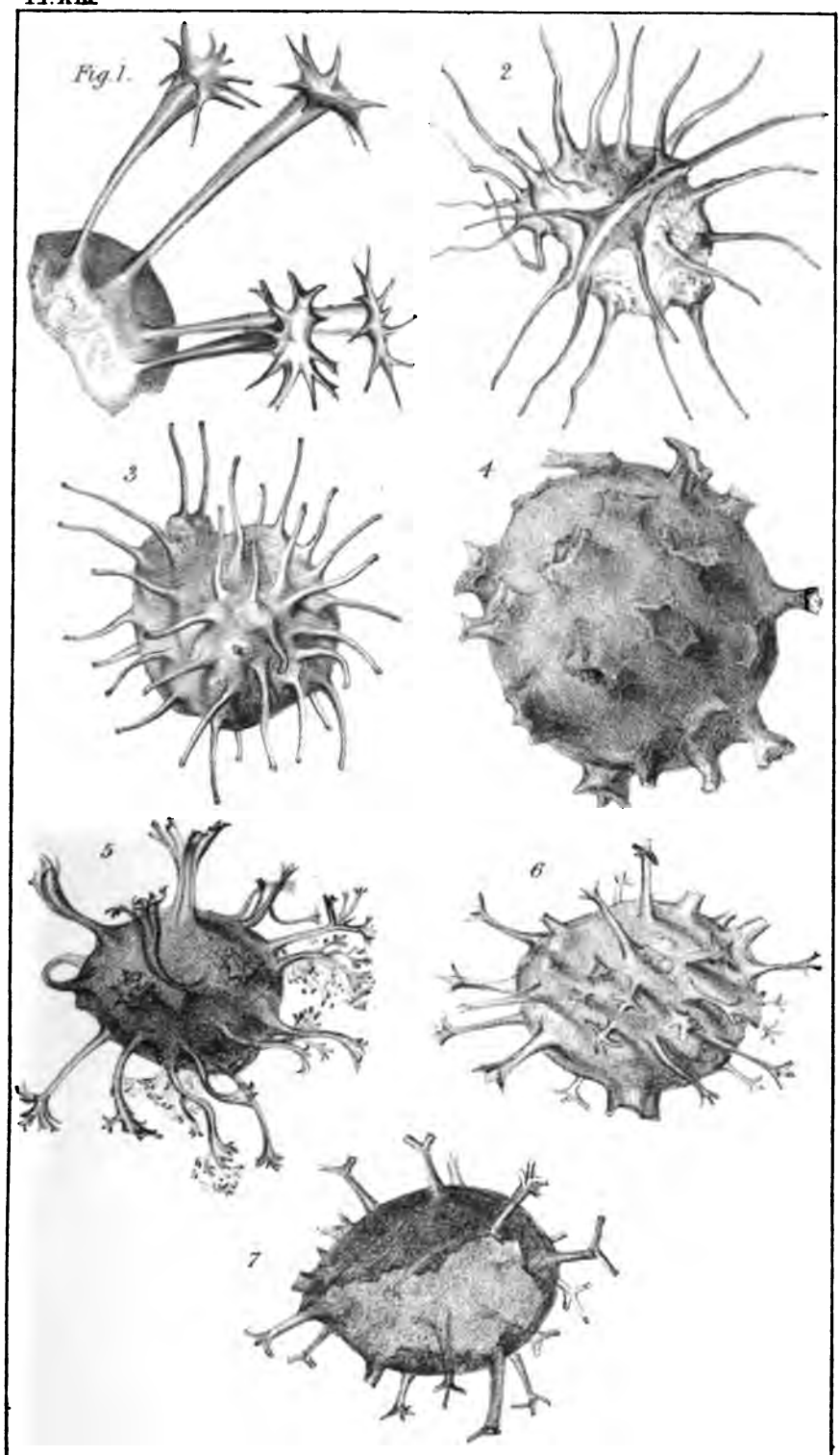
Fig. 3. This species is like *Xanthidium spinosum* (See Plate, VIII. fig. 5, Vol. i.), but is not longer than one-third of the diameter of the body, and appears to be terminated at the extremities much less acutely, as is obvious on comparing the two figures. The size is $\frac{1}{200}$th of an inch in diameter. I have seen several specimens similar to this from the same locality: the drawing is taken from the largest.

Fig. 4. This species is very similar to *X. crassipes*, although the tentacula are neither so numerous round the circumference nor so broad, and they do not exceed one-fourth of the diameter of the body, while in the specimen figured by Mr. White, they are equal to one-half the diameter. The measurement is about $\frac{1}{200}$th of an inch from opposite extremities of the tentacula.

Fig. 5. Similar to *X. tubiferum-recurvatum*, and measures from opposite extremities of tentacula about $\frac{1}{150}$th of an inch. This specimen is remarkable for its having the tentacula distorted or bent from the plane of direction, which is another proof of the flexible nature of their substance. It may further be observed that the apices of those organs assume no regularity of form—they appear to be split in different ways, as if by accident.

Figs. 6 and 7. Represent two specimens of the same species, but from different localities. Fig. 6 is from the Mediterranean, being found in the residuum of a Pinna shell from that locality: it was treated with muriatic acid to procure the siliceous shells attached to it. It appears identical with the recent *Xanthidium* from New York, as figured at Pl. VIII. Vol. i.: the tentacula are terminated in the same manner, but are not so long; the size is $\frac{1}{350}$th of an inch in diameter, and on the under side is an appendage similar to the neck of a flask, a peculiarity I have likewise occasionally observed in some fossil species. Fig. 7 was discovered in the Thames mud in company with figs. 3, 4, and 5, but is much smaller, being only $\frac{1}{300}$th of an inch in diameter.

Pl. XIII



S. W. Leonard, del. et lith.

Day & Son lith.rs to the Queen.

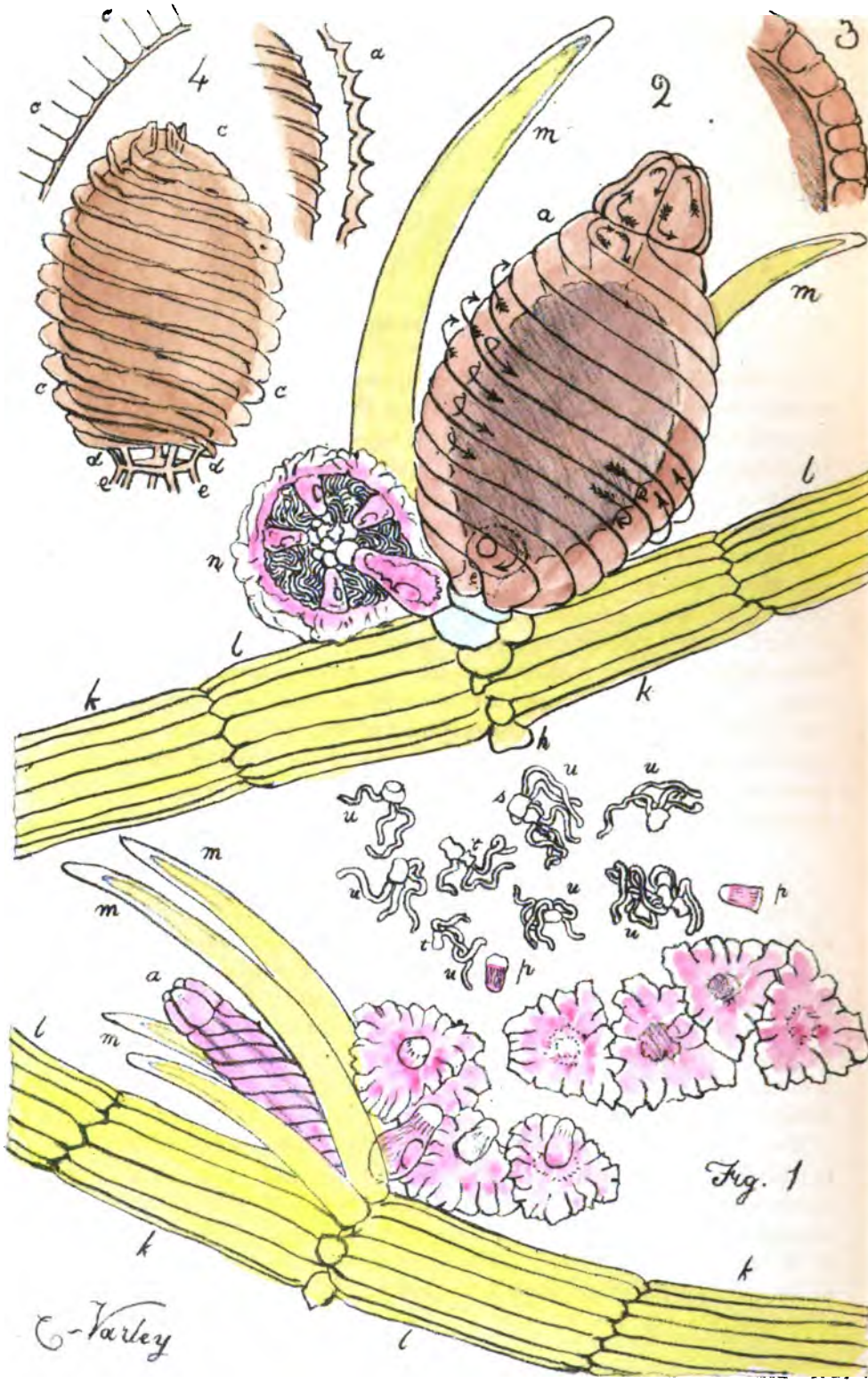

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Fig. 1
C. Varley

XVII.—*On Chara vulgaris.* By Cornelius Varley, Esq.

(Read Nov. 12, 1845).

Chara being the plant in which the important fact of vegetable circulation was discovered, and in which, from the extreme simplicity of its structure, much more is possibly observable, and with lower magnifying powers than other plants require, I trust you will favourably receive the additional observations which I now offer with a view of increasing our knowledge of that interesting plant.

Through the liberal aid of R. H. Solly, Esq., who first made me acquainted with the plant, various observations of mine on *Chara*, *Nitella*, &c., have been published in the 'Transactions of the Society of Arts.' And I have now again subjected the plant to more rigorous observations, and have made correct tracings with my graphic microscope of every circumstance that appeared to be of consequence. The result has been the finding much order in the arrangement of the different parts, together with the successive dependence of those parts on each other, and also a regular difference in the character and importance of the cells.

Description of the Seed.

The first indication of the seed on the parent plant is the seed-case, which is situated between four green sprouts, *m*, fig. 1, pl. 14. Five tubes, *a*, first appear close together, each having a terminal cell. These are twisted together spirally to the left, like a five-threaded screw, of two and a half turns, leaving a transparent and nearly parallel space between them. As the seed grows this space widens and becomes opaque, showing that the seed then fills the case. When full-grown it becomes like *a*, fig. 2.

The circulation in the spiral tubes is from the bottom to the top, at the outer side, and down again on the inner side next the seed, as shown by the arrows. I notice this particular, because in the other contiguous tubes which surround the stem and fruit-arms the course of the circulation is different. The spiral to the left is also peculiar to the seed, all the other spirals being to the right.

The five terminal cells form a little coronet on the seed: their circulation is up the outside and down the angular inside. The five tubes are not round, and are situated as in fig. 3.

The agreeable form of the seed-case is preserved by the tubes being enlarged above the seed so as to fill the space, all but a narrow, five-sided portion, which may possibly be a central cell.

The foot-stalk of the seed consists of four cells, one above the other, the first or lowest uniting it to the plant. The five surrounding tubes rise from the third cell, and this cell is remarkable as being the one that is always broken through when the seed falls off. The tubes also extend their contact to the second and fourth cells. Fig. 2, *n*, represents the globule or male flower: the bottom of its stalk is angular, projecting from between the first and second cells.

The first and second cells of the foot-stalk have vertical or oblique circulation; the third cell, *d*, is very shallow and five-sided: its circulation is horizontal. In these three I have not seen a nucleus, but the fourth cell has a globular body, *e*, going round with the circulation, as shown by an arrow.

When the seed is ripe the tubes decay, leaving it covered with carbonate of lime: the interposition of which shows that the tubes do not adhere to the seed.

The seed is one-fortieth of an inch long, and of a chestnut brown; when dry it appears gray, from the covering of lime. This coating will occasionally crack off; its section is then like *a*, fig. 4, and the seed-surface like *b*, *b*. Weak muriatic acid dissolves the crust, and the true colour of the seed can then be seen, the ridges also will then be found to have on them a very thin membrane, *c*, *c*, which grew between the five tubes.

The lower end of the ridges being continued, forms the five angles of the fourth and third cells, *d*, *d*, and *e*, *e*; the cell *e*, *e*, being broken through when the seed separates from the plant, the ridges go no lower; we may therefore consider these two upper cells as belonging to the seed, and the two lower ones to the plant.

The contents of the seed are very like wheat flour. In water the globules act like lenses, and when the microscope is adjusted to their focus, and the hand held between them and the light, every globule shews a small image of it.

The five ridges divide the skin into five straps; for on germination taking place, their ends separate neatly at the ridges, as *a*, *a*, in fig. 5, to let the young plant protrude.

The lowest roots, *b*, *c*, *d*, *e*, rise out of the same opening, and first the foot-knot, *f*, appears: it is a circle of a few transparent cells, out of which other roots, *g*, *h*, grow. The portion of the stem between this knot and the lower roots consists of one short cell, forming the lowest part of the stem.

The plant so far, being colourless and transparent, shows the circulation in perfection, as indicated by the arrows.

All the succeeding portions of the plant are elongations from the head, *i*, but should that be injured, a second or a third stem may be produced from the upper foot-knot, *f*, but none from the seed, leading therefore to the conclusion that it is a single seed and not a seed-vessel. Indeed, the whole contents of the seed appear to be absorbed by the production of a single plant, and the skin falls away empty.

Fig. 5 is a plant about a week old; fig. 6 the top or head, *i*, of one a few weeks older: its several circulations are shown by arrows. As the growth proceeds one of the head-sprouts becomes larger than the rest, and the plant thus far consists of single tubes. But from the midst of these head-sprouts the succeeding portions of the plant arise, having a covering of smaller tubes: *b** is a continuation of the largest root, *b*, to show five secondary roots, *j*, branching from it.

Fig. 7. A portion of the plant of the natural size. Every knot may produce roots, but it is remarkable that they always proceed from the upper surface of the knot and then turn downwards, so that it is not peculiar that the first roots also should rise upwards with the plant and come out at the top of the seed-skin, and then turn downwards.

Stems precisely like the original one may be produced from any of the knots; the only projections being the similar number of arms at each knot, all of which are liable to bear fruit.

That the stem and arms are tubular, and entirely covered with smaller tubes, and that the circulation can mostly be observed in these tubes, is well known. But the structure of this covering of tubes, and the peculiar mode and order of their development, are the circumstances deserving more particular attention.

The number of fruit-bearing arms in each cluster is variable, seven, eight, but most frequently nine are found, and as I have occasionally found ten, I cannot correctly state the number due to a complete plant.

Nine blossoms and seeds generally grow on each arm, but I have sometimes had the plant with two globules and two seeds at each

joint of the arms, and as the plant elongates with an indefinite number of knots, it must be very productive of seeds.

In the first place I have to remark that the number of arms, *h*, *h*, at each knot, has a remarkable connexion with the tubes covering the stem, see fig. 8, and these tubes are of two sorts, primary and secondary. Under each arm, *h*, one primary tube, *d*, descends, and one also ascends above each arm: these last meet other primary tubes descending, set midway on the stem, and each of these divides into two secondary tubes, so that with nine arms there will be nine primary tubes and eighteen secondary ones, making twenty-seven around the stem, while with seven arms there will be only twenty-one.

Secondly. The primary tubes are formed of several lengths, *a* and *b*, *b*, *b*, joined together in one line by very peculiar cells, *c*, *d*, fig. 10, and these primary tubes are joined to the plant by their first cells only, *a*; and the secondary tubes, *e*, *f*, are still more detached, their sole connexion with the primaries being by means of their small cells *c*, *d*, from which they emanate, like side-leaves from a central stalk. One of the ascending and two of the descending sets are pulled away to show their structure.

Thirdly. The ascending and descending primary tubes never come into contact with each other, but reciprocally end between the opposite secondary tubes.

Fig. 8 shows this alternate junction midway on the stem, and fig. 9 the general appearance of this alternate meeting on an extremely young stem.

Fourthly. All the covering-tubes grow close together, with a slight lateral adhesion, and so form a coat to the stem, but they are prevented from touching it by a layer of carbonate of lime, which crystallizes round the stem beneath the coating.

Fifthly. The primary tubes are much larger than the secondary ones and thus give an angular form to the stem, as shown in the section, fig. 11: this allows more room for the coating of carbonate of lime beneath the secondary tubes, and therefore it is most frequently to be seen through them, as indicated in fig. 8.

Sixthly. The covering-tubes sometimes so much outgrow the stem as to form a very loose jacket, like fig. 12, their extreme ends, *a*, both at top and bottom, continuing united to the plant.

In other cases the stem out-grows the covering tubes: and then bends out, as in fig. 13, in which case it resembles a bow, the tubes forming the string. This shows the tubes to be detached from the

stem, except at their ends, and gives the most favourable opportunity of observing the various circulations. All the parts of these figures, 12 and 13, were alive and in most healthy circulation when the drawings were made.

The cells, *c*, *d*, are the smallest, and the tubes, *a*, *b*, *b*, the largest features on the stem (figs. 8, 10, 12, 13 and 27), *a* and *b* are primary, being united to the stem and bearing the secondary ones, *e*, *f*; yet their small cells, *c*, appear to be of more importance, as they are well developed before the others come into sight, and are then so nearly of their full size as to form almost the whole bulk of the youngest buds. Their early maturity, and their being stationary during the future growth of the plant, marks them as peculiar and important cells, deserving of much farther examination.

Fig. 14 represents the whole of three upper and three lower lengths of covering-tubes, with their exact number of cells, correctly drawn from a very young stem, but spread flat. The alternate position of the upper and lower sets is also shown. Fig. 15 is a side view of one length. In these figures the secondary tubes, *e*, *f*, are the smallest objects, and the primary tubes, *a*, *b*, are the next in size, being shorter than they are wide, and not any larger than the cells, *c*, yet the cells, *c*, appear to be as complete as they are ever likely to be.

Fig. 16 is a careful tracing from nature of a very young stem, a little more advanced than fig. 14. Here the end cells of the primary tubes have just passed each other, and have mutually entered between the opposite secondary tubes. This avoidance of contact between the upper and lower primaries is remarkable.

There is also a series of globular cells, *g*, *g*, close under the arms, which arrive at maturity very early, and their clusters correspond with the arms, there being two clusters to each arm: these are shown in figs. 8, 16 and 27.

The fruit-bearing arms in their early state of maturity also possess features of similar importance: these are the little studs, *h*, *h*, and the terminal cells, *i*, which in the full-grown arm, fig. 18, are but small, but in the very young arms, figs. 19 and 22, are very large in proportion, when compared with the former.

Fig. 17 is one arm stripped of its covering, to show the ten long cells, *j*, *j*, and the terminal one, *i*, which compose it. Fig. 18 is the same with its proper covering.

It may now be stated that the covering tubes, *k*, *l*, are formed at the same time with the central tubes, *j*, *j*, and that both grow together. If in any case the central tubes or any part of them are bare, they do

not become covered, or if the tubes lose their adhesion to each other, they do not again unite, and where there are no covering tubes no fruit is produced.

In figs. 17 and 18 the central tubes, *j*, are long, and the covering-tubes, *k*, *l*, rise half-way up one length and descend half-way down another length, being met and joined by similar tubes from the joints above and below, thus they are half the length of the central tubes, and the studs, *h*, are very small, but in the very young arm, fig. 19, the central tubes, *j*, are shorter than they are wide, and the outer tubes half their length, yet the cells, *h*, are as round and plump as they ever will be, and appear very large, being nearly of their full size, and the terminal cell, *i*, looks gigantic, being three times as long as the cells, *j*.

Each of the round cells, *h*, forms a centre for four of the covering-tubes, *k*, *l*, as shown detached in figs. 20 and 21, and in their places, 18 and 22, two up and two down. Each joint may have either six, seven, or eight of the studs, *h*, giving, respectively, twelve, fourteen, or sixteen tubular cells for the circumference: twelve and fourteen are the most frequent numbers. On the inner or upper side of the arms there are more studs at the joints, four elongating into sprouts, among which the globular blossom, *n*, and the seed, *a*, grow.

These covering-tubes fit so closely to each other as to form a sound case, yet carbonate of lime will occasionally crystallize under them, showing their connexion with the plant to be at the studs, *h*, only.

The cells, *c*, on the primary tubes of the main stem, have the usual lining, paved with minute, mostly round, green vesicles, darker in colour, and so closely placed, that we can scarcely see anything moving within, and they have a smaller cell, *d*, under them. The studs, *h*, on the arms, in these particulars, are like them, but under them, around the joints, are peculiar clear cells, with no fixed vesicles: these are filled with round green vesicles, in quick circulation, and from the largest of these cells the blossom and fruit grow.

A number of the peculiar cells also within the large knots, close under the clusters, *g*, are filled with circulating globules.

On this part of my subject I have first to notice that the marked difference of these cells is, that whilst the chief portions of the plant have a nearly colourless fluid, in which are various sizes and forms of particles, and a lining, on which elongated, green, fixed vesicles are disposed as it were in regular spiral order, the fluid following their course, the peculiar cells appear to have no such fixed vesicles, but are filled with green globules, of regular size, and in quick circulation.

Secondly. That all the cells have an extremely thin lining, the slightest wound of which is death to that cell. This lining is in most cases regularly paved with vesicles, the colour of which determines the colour of that portion of the plant. These appear to regulate the circulation; for when any accident damages or removes them near the boundary between the to-and-fro currents, some of the fluid will anastomose, *i. e.*, will pass the boundary and return as shown by the arrows, in fig. 23, instead of continuing its course to the end and there returning.

The specimen from which this was drawn had been injured; it became healed within a fortnight, new vesicles grew, and again covered the place of the wound, the circulation then became regular, none going over the boundary. The place appeared fresh, the new studs being paler and rather smaller than the old ones.

Thirdly. That there are two fluids in each cell that do not intermingle. The central fluid is passive, and thinner than the circulating one, which it supports against the lining, and to which it seems to adhere and along which it appears to slide, dragging the central fluid with it. This I believe to be a law of vegetable circulation.

Fourthly. That gravity affects the visible masses of matter in the central passive fluid, but not in the circulating fluid. In whatever position the plant may be placed, circulation will go on well. But let the plant be put horizontally, as in fig. 24, with the side that has large masses uppermost, these will fall to the lower side and return with that current; again change the position, they will fall back into the first current, and be carried along with it. This proves that there is no partition between the two currents; accordingly, when a mass happens to be in the centre, it only revolves without changing its place, as shown in fig. 25. This fact may be most frequently seen in *Nitella translucens*, from its being four times as thick, and always without the covering of carbonate of lime. At the bottom of the figure globules have accumulated in sufficient number to obstruct each other's rising.

Fifthly. That the cells of the plant are of four kinds, each possessing separate qualities.

1. Those of early maturity.
2. Cells with green vesicles in motion, and no fixed ones.
3. Cells that have a flexible mass sliding round in the circulating fluid.
4. Cells with no extra feature in the fluid.

Those arriving at early maturity are the little cells, *c*, in the primary tubes, the globular clusters, *g*, under each knot, the cells, *h*, on the arms, and the terminal cells, *i*.

The covered cells having green vesicles in motion, in the knots and in the joints of the arms, form the second class.

The third class of cells having a flexible mass or cytoblast sliding round, are the primary tubes, *a*, *b*, *b*, the central tubes of the arms, *j*, *j*, the nine stalks in the globule, and the fourth cell in the bottom of the seed. In these the circulation is vigorous.

Those of the fourth class are the secondary tubes, *e*, *f*, around the stem, the tubes, *k*, *l*, which cover the arms, the tubes around the seed and the sprouts amongst which the seed grows, and generally all the terminal cells. In these the circulation is slower, and often requires a high power to see it.

The roots have a flexible vesicle, which becomes lodged just under the surface of the matter deposited in their lower ends. This is shown at *o*, figs. 5 and 27.

Whilst writing this, a seedling under the microscope appeared beautifully transparent, had many distinct forms of different shapes and sizes in the main stem, but no flexible vesicle gliding along.

Fig. 25* is a section of the main stem,* without its covering-tubes, to show the spiral indents, *p*, *p*, to which the lining adheres: they mark the boundary between the ascending and descending currents.

Fig. 26. A portion of stem out of which the lining was floated: it came out in two portions, *q*, *q*, being rent at the line of adhesion. From the *Nitella* the lining will float out whole, as shown in fig. 26*, at *q*, *q*.

Fig. 27 is an edge-view of a portion of the lining of *Nitella translucens*, magnified 700 times. The studs which pave the lining are oval whilst living, but when taken out they become round, and the lining shrinks. These studs have other distinct green vesicles within them, various in number, as at *v*, *v*. There was a very singular addition to this lining, both on the outside and inside, namely, the clear, thin, globular masses, *w*, *w*. They were extraordinary from

* Any ordinary cutting to obtain sections would squeeze the tube flat, and spoil it and the lining, so I took advantage of the fact, that water, when struck quickly, resists like a solid, and therefore laid the *Chara* on smooth wood, just covered with water, then, with a sharp knife, made suddenly a number of quick cuts across it, and so obtained the various sections required. Wet a slip of glass and turn the wood over so as just to touch the water, and the sections will fall from the wood on the glass, and thus be ready for the microscope.

there not being sufficient room between the tube and the lining for them to appear of that shape when in their natural position. They were clear and spherical as soap-bubbles. To account for them we may observe that the central passive fluid is soluble in water, the circulating fluid which glides along in close contact with the lining is not so, and from this appearance it is probable that the outer or third fluid between the lining and tube is also not soluble, and so comes out with the lining, and assumes the globular form here shown.

Fig. 27* was traced from a stem so clear as to show the various circulations, as indicated by the arrows; the flexible oval vesicle is visible in all the primary tubes. All these circulations, as well as those in the arms, are up one side and down the other, and not like those in the seed, up the outer and down the inner surface.

I have not found any rule to say which shall be the ascending or descending sides. In some places the contiguous currents go the same way, in others they are contrary, as will be seen by the arrows. In this specimen there is the same system in all the secondary tubes, but in other specimens this differs.

On the fruit-arms four sprouts, *m*, appear at the joints: the globular cluster of florets projects below them, as in fig. 18 and figs. 1 and 2, and the fruit, *a*, rises up between them, as in figs. 1 and 2.

When two globules and two seeds grow together they are preceded by six sprouts, *m*.

The globular blossoms, although small, are rich in variety, and contain the most extraordinary features that have hitherto been observed as connected with vegetation. In 1833 I first saw them, and a description of them was published in the 'Transactions of the Society of Arts' for that year, vol. 50. But I have since examined them with higher powers, and having correctly traced what I saw, I am enabled now to add many additional facts.

In that description the seed-stalk was stated to consist of four cells, one above the other: the globule projecting from the first and second, as in fig. 2. I have now to add that no part of its stalk is uncovered, a small portion being surrounded by the cells of the plant, and the remainder inserted into the globule.

Fig. 28 represents a full-grown blossom, *n*: it appears like a red ball in a transparent cover; but it is not so, the colour being in the cover, and the space within is hollow, filled with transparent objects. The cover is formed of eight segments, fig. 1, each having its own stalk radiating from a centre, as in fig. 2. As the globule ripens, the segments become flat, and separate from each other, in the man-

ner shown in fig. 1. The stalks will also separate from some of them, as at *p*, *p*, and the whole of these parts will remain alive for two or three days. This is the only opportunity for seeing their circulations.

Figs. 29 to 34 are as seen with a power of 300, from tracings carefully made, whilst the portions of globule were magnified 880 times, consequently 29, the main stalk, and 30, an edge-view of one segment and its stalk, *p*, are in exact proportion to each other. The stalks have linings, paved with minute, elongated vesicles, in the direction of their circulation, which they appear to regulate, and they very distinctly show the large, flexible vesicle, *q*, gliding round in close contact, like a slug; for as it always keeps in close contact with the side, every part changes in succession, to fit the angle at the bottom of the stalk, and whilst doing this its motion is impeded, so that the fluid keeps passing it till it has got by, and then both move together, and in like manner at top its flatter side becomes convex, and its round back becomes flat whilst passing under the dome.

The only coloured portions of the globule are in the stalks and at the inner surface of the segments, *r*, *r*, on which bright pink balls, perfectly round, and of extreme minuteness, are deposited. The fluid in the segments is so perfectly clear that nothing of its motion can be seen.

The centre of the globule is occupied by a few clear balls, from which the eight segmental stalks radiate, as in fig. 2, and from which other clear vessels, *s*, fig. 31, project, and again from these, smaller ones, *t*, *t*, project, and lastly, from these, the numerous filaments, *u*, *u*, ramify in every direction to fill all the space in the globule. Fig. 34 shows a stalk, *p*, which had left its segment, but retained some of the central features, *s*, and *t*, *t*, *t*: its circulation continued in full activity.

The ripe globule spontaneously opens, as in fig. 1. The filaments also expand and separate into clusters: they are so numerous that I have not been able to decide upon their exact number.

The tube-like filaments, *u*, are divided into numerous compartments, in which are produced the most extraordinary objects I have ever observed of vegetable origin. At first they are seen agitated and moving in their cells, as in fig. 32, where they are coiled up in their confined spaces, every cell having one. They gradually escape from their cells, by what means or through what opening I have not been able to ascertain. The whole field soon appears filled with life: they are generally spirals of two or three coils, and never become straight, though their agitated motion alters their shape in some

degree. They have at their foremost end a filament so fine as only to be seen by its motion, which is very rapid and vibratory, running along it in waves.

These objects, although they have every appearance of life, swim about with no apparent consciousness of each other, or any choice of direction. Their filament-end goes foremost, when they come into contact with each other they become entangled, and their motion is hindered: this does not cause any retreating action or attempt at separation, except by accident.

They appear to be an example of life without self-will or choice. Their motions gradually slacken, and in about an hour they become perfectly still.

If a globule be forcibly opened before it is ripe the filaments will appear like fig. 33, giving no indication of life.

I have now detailed the chief observations of *Chara vulgaris*, made by me with a view of explaining its structure, from the seed up to the globule, with the circumstances which in due order usually precede the production of the fruit, but there is great latitude in this respect, probably from some seeds being fructified by the produce of other globules.

Recapitulation.

First. It has been shown that there is a regular correspondence in number between the fruit-arms and the tubes which cover the stem.

Second. That there is a systematic division of those tubes into primary and secondary, the joints of each primary tube bearing two secondary tubes.

Third. That these tubes only lie against the stem, having no union with it except at the end nearest to it. Yet that their proper growth depends on their adhering to each other laterally, so as to form a case round the stem.

Fourth. That one class of cells arrives at maturity early, and that their size remains stationary during all future enlargements of the plant.

Fifth. That although the ascending tubes have to keep in union with the descending ones, yet the primaries avoid each other, and always insert their ends between two of the secondary tubes.

Fig. 16 is covered by the usual number of cells, and the order is so exact, that by counting the fruit-arms, which are nine, and the num-

ber of cells in any one pair of the primary tubes, the whole number of cells in that portion of the plant may be known. In this instance the stem is covered by 603 cells, most systematically arranged.

Sixth. That there exists a class of cells at the joints, having equal-sized, green globules circulating in them, instead of their being attached to the lining.

Seventh. That there are two divisions of the cells. Those having a flexible vesicle gliding round, and those having none, these latter having a slower and less visible circulation.

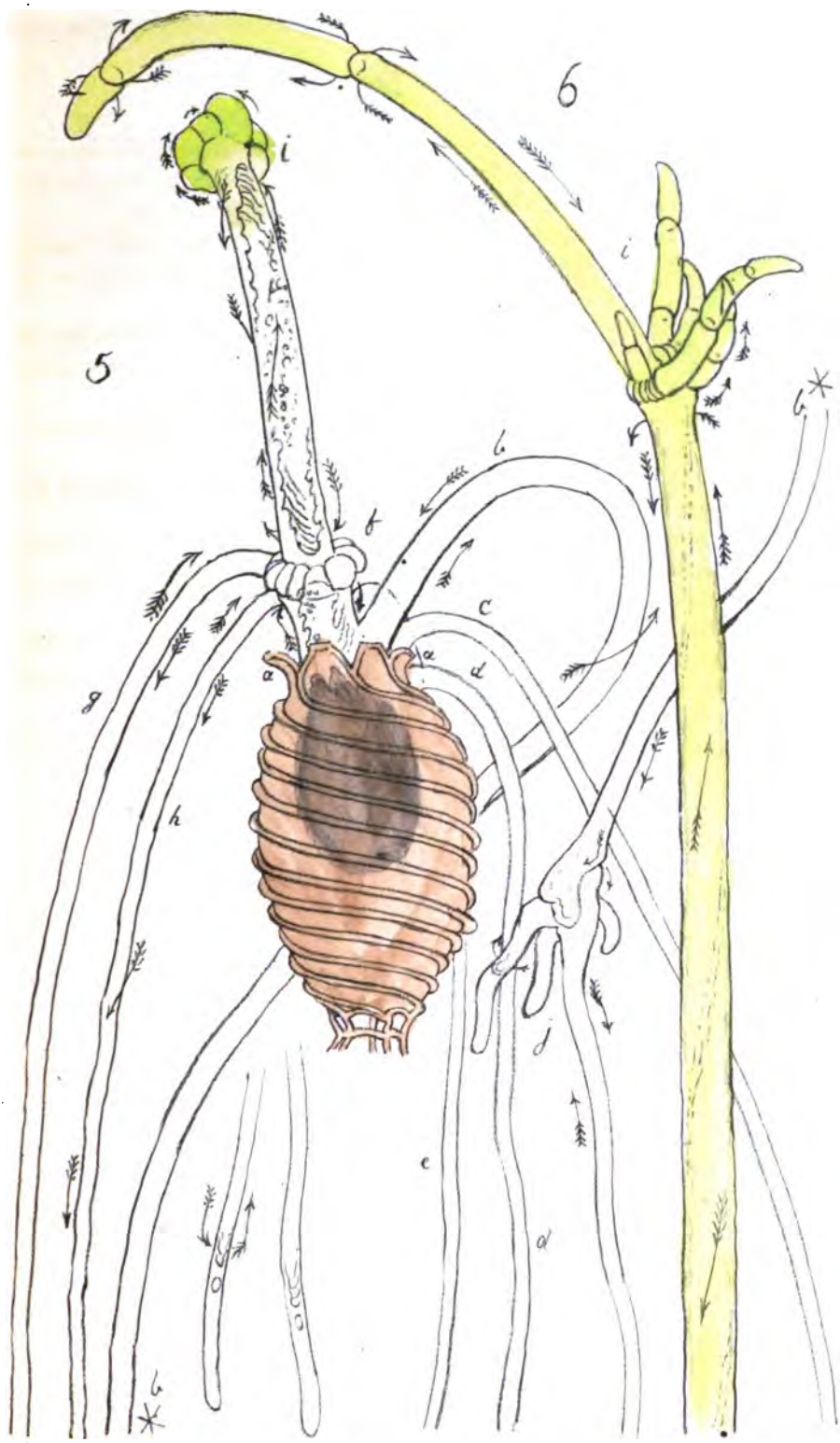
Eighth. That the globule on the main stalk when complete invariably consists of eight segments.

Ninth. That the masses in the central fluid are affected by gravity, but not those in the circulating one.

Tenth. That the paving of green vesicles arranged in such order on the lining is apparently the regulator, if not the primary cause, of the motion of the fluid, as shown by fig. 23.

Eleventh. That all growth is from the upper side of the knots and not from below, the roots rising from the top and then bending downwards.

Twelfth. That the internal structure of the globule produces in great number certain very singular moving bodies.



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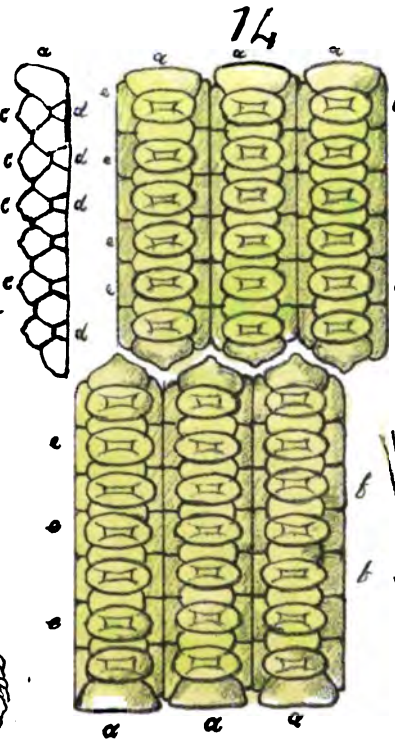
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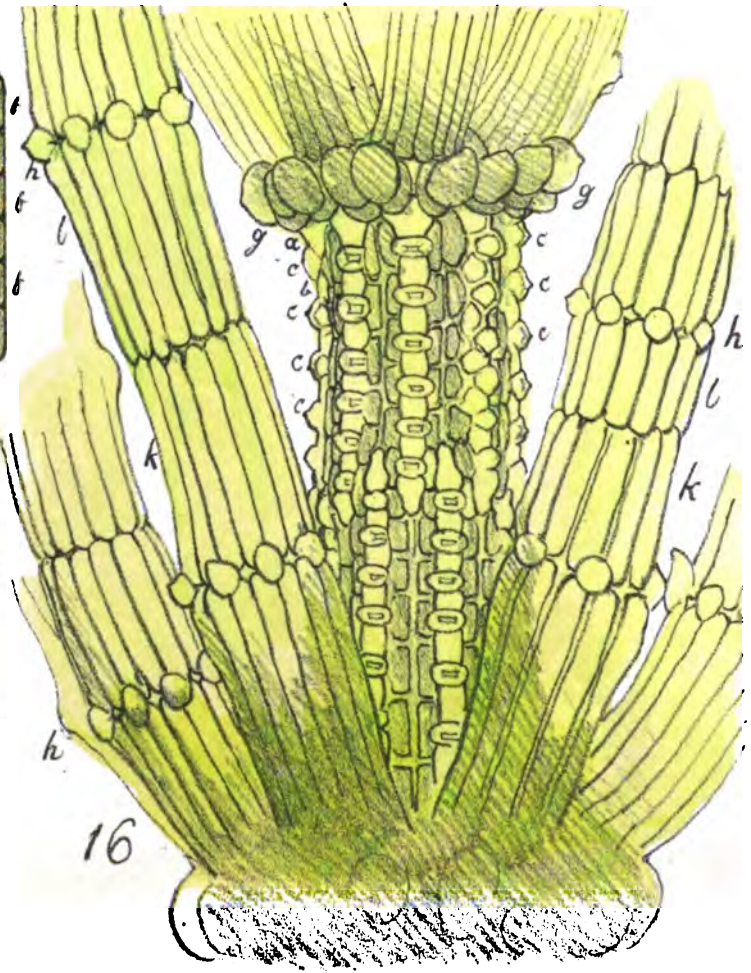
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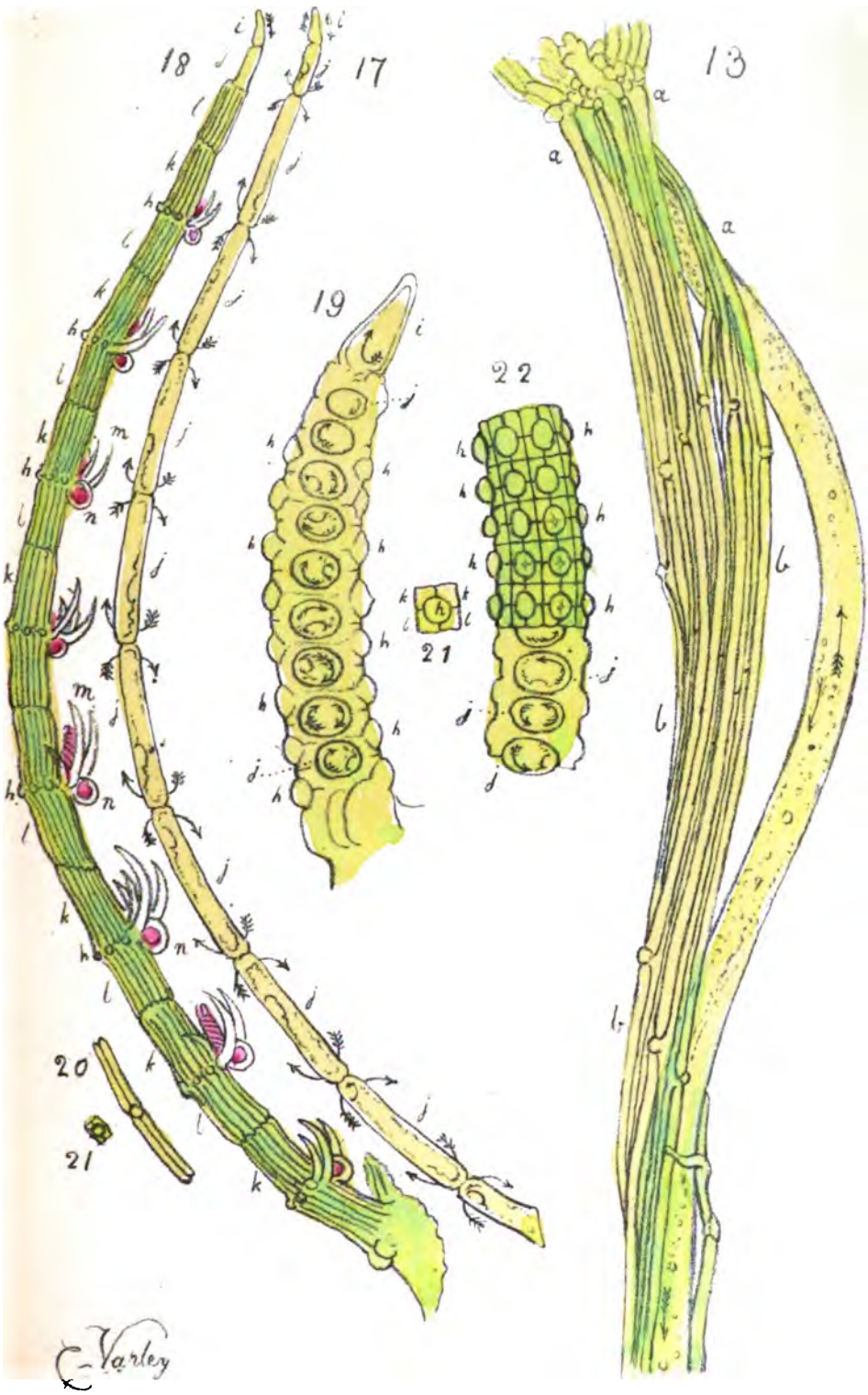
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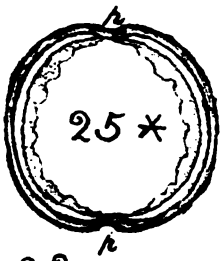

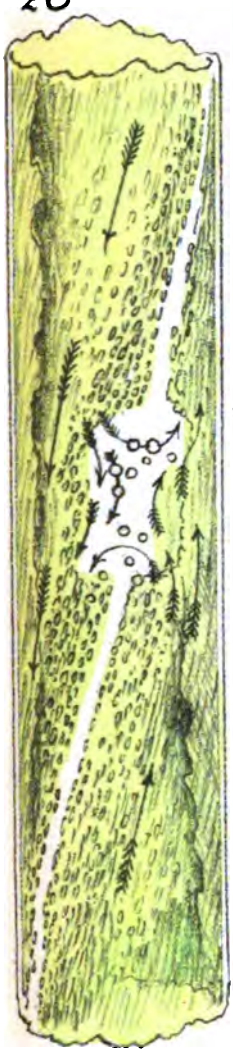

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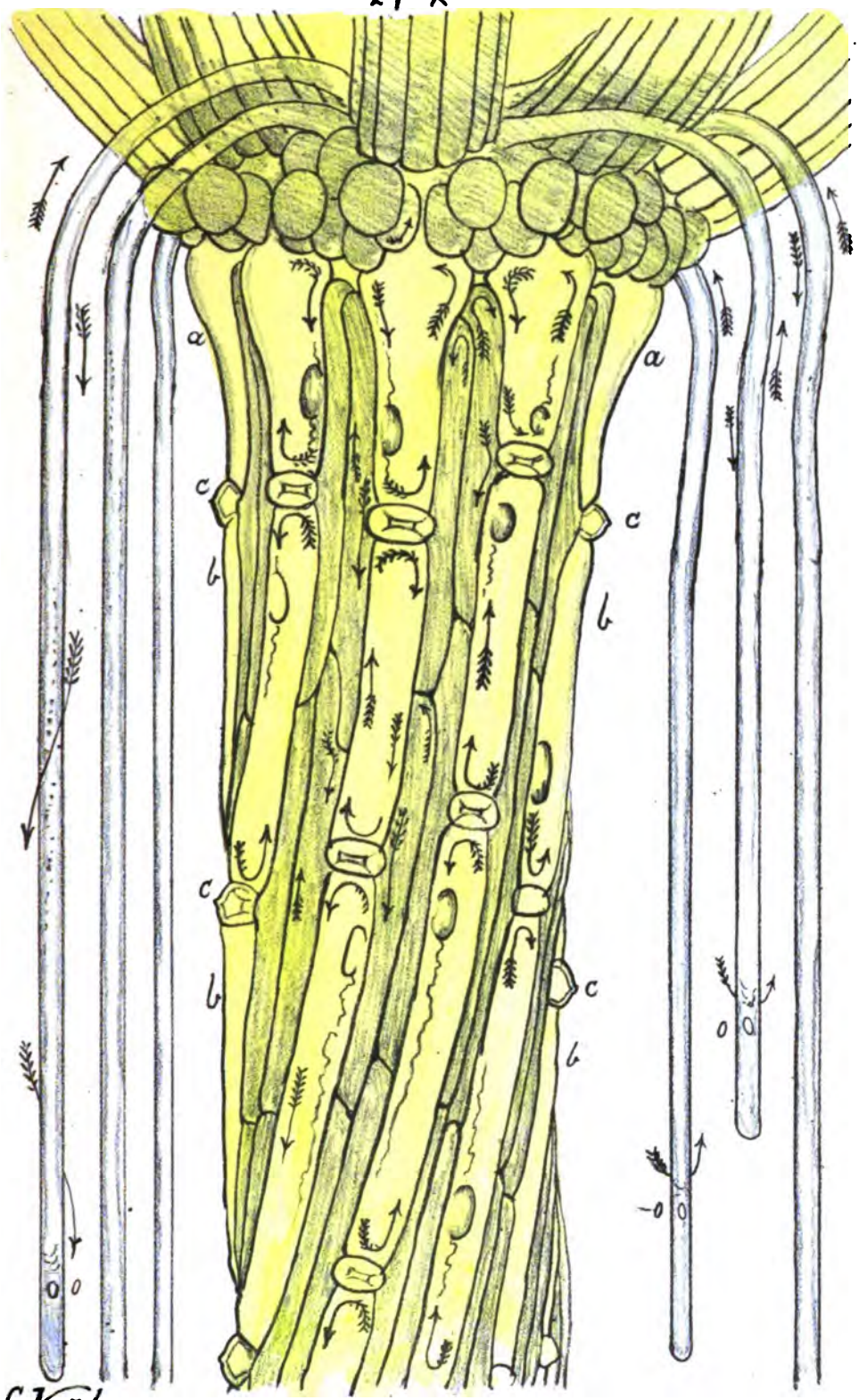
C-Varley

27 *



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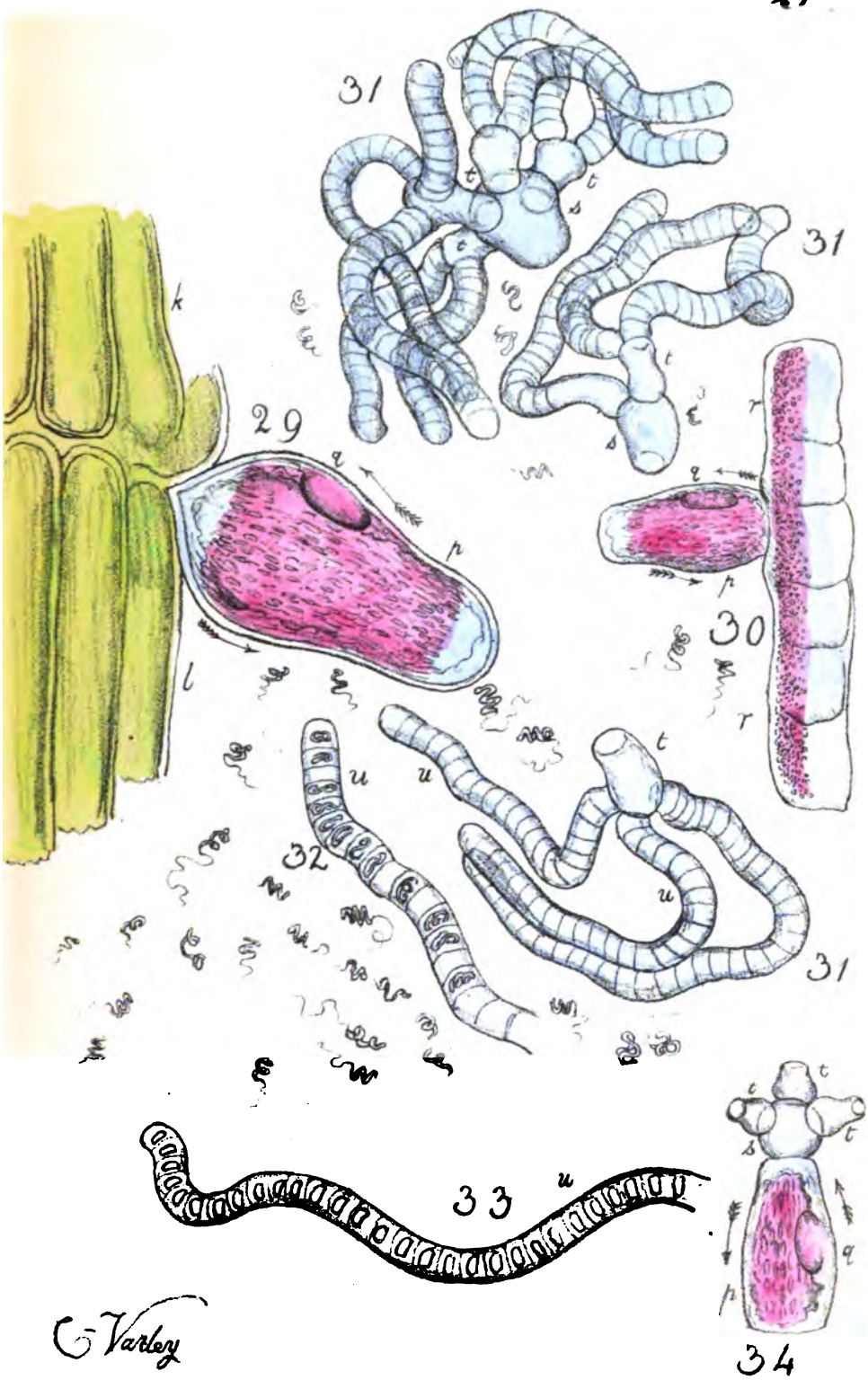


G. Varley

XVIII.—*On the Structure and Formation of the Nails of the Fingers and Toes.* By G. Rainey, Esq., M.R.C.S., Demonstrator of Anatomy, St. Thomas's Hospital. Communicated by John Quekett, Esq.

(Read April 21, 1847).

The nails being probably too much regarded by physiologists merely as a modification of cuticle, and as resembling it in all their essential characters, have not been either very minutely or clearly described.

Although these organs are so intimately connected with the skin as very properly to allow of being classed with its appendages, yet being designed to perform a function peculiar to themselves, and different to any one performed by the cuticle, it must be admitted that they require an express organization. Also, the vascular surface upon which the nails are formed, their matrix, must require a disposition of blood-vessels different from that of the cutis of other parts, where it is merely covered by the ordinary cuticle.

The object of this paper is to show that the nails consist of at least two distinct structures: one proper to them, the horny structure, and the other the cuticular one; and also that their matrix possesses one set of vessels expressly for the secretion of the horny part of the nail, and another set for the formation of the cuticular portion; and that besides these, there are other vessels differing in their characters and arrangement from the preceding, and probably intended to furnish a material, intermediate in some of its properties between horn and cuticle, and destined to blend these together, and thus to preserve their union during the growth and protrusion of the nails. However far this idea may be correct, the anatomical fact of there being these three different arrangements of vessels is indisputable, as may be seen in Pl. 22, fig. 1, taken from preparations of the injected matrix of the nail in the cabinet of the Microscopical Society.

Structure of the Nails.

If a thin, vertical section be made lengthways through a finger-nail from its posterior to its anterior or free margin, as shown in Pl. 22, fig. 2, the external or dorsal surface of that portion of it which was

lodged in the groove between the matrix and the semilunar fold of skin projecting from the dorsum of the finger, is seen covered by a thin layer of cuticle, which extends backwards as far as its posterior border, which is generally jagged and uneven, and forwards upon its dorsum. This portion of cuticle is immediately continuous with that overhanging the root of the nail, and although it is not inseparably blended with its horny substance, yet it is sufficiently adherent to be carried forward with it during its growth, and to remain intimately attached to its dorsal surface until it is worn off by friction or some other mechanical cause. The palmar surface, near to its free border, is also seen covered by cuticle, which in like manner divides into two parts, the one becoming continuous with the cuticle covering the end of the finger; the other passing backwards along the palmar surface of the nail as far as the lunula, where it imperceptibly terminates. This portion of cuticle gradually diminishes in thickness as it extends backwards, and is more intimately connected with the horny part of the nail than was the cuticle on its dorsal surface. Between these layers of cuticle the proper or horny matter of the nail can be distinguished, presenting fine, nearly parallel, and generally semi-elliptical lines, with their concavity looking in different directions in different parts of the same section, and also a multitude of darkish-looking corpuscles, when viewed by transmitted light, of various forms and sizes. These compose the substance of the horn of the nail, and the lines are the cut edges of the laminæ of which it is made up. The horny part of the nail does not increase in thickness after it has extended beyond the lunula, the apparent increase of the nail anterior to this point being derived from the cuticle formed upon the anterior part of the matrix.

The Matrix of the Nail.

A mere inspection, even in the living subject, of the parts situated beneath the nail, is, in consequence of its transparency, sufficient to give a general idea of the relative vascularity of the various parts of its matrix. The upper part of the matrix is seen to present a pale, semilunar space, called the lunula. The greater part of the lunula is concealed by the semilunar fold of integument which projects over it; but extending a little below this fold, the lower portion of the lunula is visible, presenting a curved border, with its convexity looking downwards. Immediately below the lunula, and circumscribing its inferior limit, the matrix has a reddish colour, which gradually be-

comes fainter towards the free margin of the nail, but which deepens considerably where the nail becomes detached from the integument.

When the matrix is fully injected and the nail removed (see Pl. 22, fig. 1), the part corresponding to the lunula presents several rows of convoluted capillaries: the individual convolutions have different degrees of complexity, from a simple loop a little twisted around itself, to a complex tuft of vessels. These rows have their direction from above to below, they are all slightly curved, being concave towards the median line of each nail, and the most external ones are nearly parallel with its lateral margins; (see Pl. 23, fig. 7). These, being the vessels which secrete the horny part of the nail, may be called the horn-vessels. Superiorly these vessels are separated from the rich plexus on the fold of integument which overhangs the nail, by a fibrous and almost non-vascular groove, in which the free border of the nail was lodged, and where the cuticle covering its root terminates. A few vessels, however, pass across this groove from the horn-vessels to the plexus just mentioned. Inferiorly the horn-vessels communicate with quite a different arrangement of capillaries, which run in a more straight course, and are much more crowded together than the horn-vessels. These vessels run nearly parallel with one another, in a direction from behind forwards, and being very near together render this the most vascular part of the matrix, and produce that redness immediately below the lunula upon which the form and degree of distinctness of its lower border is dependent. Just below these vessels the surface of the matrix begins to be raised into numerous plications or folds, passing directly forwards, and increasing in depth as they approach the free extremity of the nail, where they become continuous with the raised lines observable on the ends of the fingers. These plicæ consist each of a fold of basement membrane, enclosing a series of loops of vessels. At first these loops are small and simple, but they become larger and more complex as they advance towards the end of the finger, where they are continued from the ridges of the matrix of the nail into those of the skin of the finger, in which they are generally very complex. When the nails are *in situ*, these ridges are received into corresponding grooves in their inferior surface. Near the part of the matrix where the plicæ commence, several distinct circular or oval openings are sometimes seen passing for some depth beyond the surface, and appearing like follicles or lacunæ; (see Pl. 23, fig. 7). These are frequently closed by the apposition of the adjacent plicæ, and thus their presence is rendered doubtful, but they can be seen very distinctly either when some of the

material which they contained has been recently removed, or still remains within them in the form of whitish, globular masses. The situation of these lacunæ, where the openings themselves are not apparent, can be distinguished by the plexus of capillaries in their vicinity, in the areolæ of which their openings are situated.

The Growth of the Nails.

The growth of the nails is effected exclusively by the continued secretion of horny matter at their roots, the particles of which, while in the act of being deposited, force forwards all those which had been deposited previously. Hence the nails grow only in one direction, namely, from behind forwards. This fact is evident from the well-known experiment of making two marks with lunar caustic near the root of a nail, and observing their progress towards its free border, when they will be seen to preserve always the same distance from one another, on whatever part of the nail they may be situated. Now from this fact it is obvious that the proper material of the nail is secreted from the vessels situated the most posteriorly of the three sets just described, that is, from the convoluted capillaries situated beneath the lunula, the position of these vessels being such as to render it impossible that a substance constantly separated from the blood within them, and deposited on their exterior, can do otherwise than continually protrude forwards the whole of a nail at the same time. For the horny matter proceeding, doubtless in a fluid state, from these convolutions, is, on quitting them, so compressed between the fold of skin which overhangs the root of the nail, the posterior part of the matrix itself, and the fibrous groove connecting these, as to be prevented passing in any direction excepting forwards, and even this it cannot do without displacing the whole of the nail at the same time, as before shown. Hence in this manner a direction is given to the nail forwards, and the other convolutions adding at the same instant the horny matter secreted from them, this part of the nail is completed, and its thickness determined, which therefore does not increase afterwards. This part of the nail being now formed, has to pass over the other portions of the matrix, from which it receives the cuticle requisite to connect its inferior surface with the cuticle at the end of the finger. In the vertical section of nail represented by Pl. 22, fig. 2, the cuticle on the inferior surface of the nail is seen to extend no further back than the lunula. Also, in the transverse section through the nail, a little behind its free edge, represented by Pl. 22,

fig. 3, the lines indicating the cut edges of the horny laminæ are seen terminating at the arches of cuticular cells, upon which they appear to rest, without being continued into them, whilst in the transverse section through the nail at the lunula, represented in Pl. 22, fig. 4, the lines showing the cut edges of the horny laminæ are seen to be continued into the small projections which are situated directly upon and between the convolutions of the horn vessels. Besides the microscopic examination of these substances, a difference in the properties of that covering the vessels of the lunula, and the other lying upon the vessels of the other parts of the matrix, is shown by the facility with which these admit of being separated one from the other on removing the nail from its matrix. Sometimes, after such a separation, a layer of material remains upon the vessels of the lunula exactly corresponding to them both in form and extent, those of the other parts of the matrix being perfectly freed from all secretion, whilst at other times the material remains, after the detachment of the nail, upon the latter vessels, those of the lunula being completely denuded. From all the facts which have been stated, I feel satisfied in my own mind that the vessels of the lunula are exclusively those which are employed in the secretion of the horny part of the nail, and that the vessels in the longitudinal folds of the matrix which are continued into the ridges of the skin, secrete merely cuticle. I have no opinion to offer respecting the function of the lacunæ and the straighter vessels, namely, those situated between the vessels of the lunula and those contained in the longitudinal plicæ; excepting that vessels intermediate in their position, as well as in their anatomical character, between those secreting the horn and those the cuticle, may possibly serve to furnish a substance intermediate in its properties between the horny and cuticular part of the nail, and in this way cause a more intimate union between these two substances at the instant of their secretion, and preserve more completely the connexion of the nails with the cuticle during the progress of their growth and protrusion.

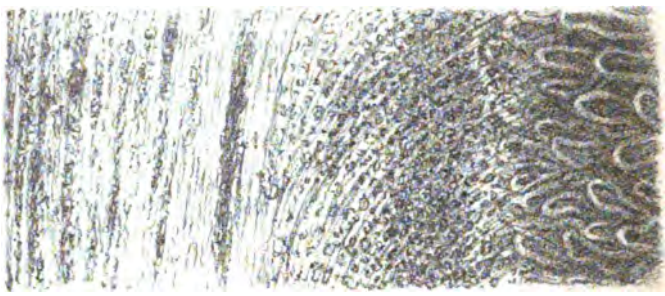
XIX.—*Observations on the Shepherd's Purse Coralline of Ellis,* (*Notamia bursaria*, Fleming). By George Busk, Esq., F.L.S.

(Read October 27th, 1847).

Several particulars connected with it, conspire to render the *Shepherd's Purse Coralline* one of the most interesting subjects of its class. The elegance of its habit, the peculiar conformation of the polypidom, and the great comparative transparency of its texture, all invite the attention of the observer. I believe also that the study of this species will, in particular, serve hereafter to throw considerable light upon the structure and functions of those mysterious organs, the "Bird's-head" processes, found upon so many *Bryozoa*, &c., and with respect to the true nature of which we are as yet so much in the dark. Another point of interest also connected with this species consists in the circumstance that it may in some measure be regarded as a new subject for investigation, for since its original discovery and description by Ellis, in 1755, it appears almost to have escaped the notice of naturalists. The description of it given by the Father of Zoophytology is still in reality the only one extant; all subsequent notices having evidently been derived either from that source, or from reference to his figures, and not from actual observation of the creature itself, at all events, in the living state. Neither am I aware, that, with the exception of one or two outline figures, by Dr. Clarke, given in the plate (Pl. LI.) of this species in the last edition of Dr. Johnston's valuable work, there has been any addition to, or at least any improvement upon, Ellis's original figure. His description, therefore, and representation, like all those traced by the pen and pencil of that excellent observer, though graphic, and as far as his means of observation allowed, correct, will, as may naturally be supposed, admit at the present time of considerable amplification and amendment. The only sufficient reason that can be assigned for the apparent neglect into which this *Bryozoon* has fallen, is its comparative rarity. Whether this rarity be real or not, I am unable to decide, but I am inclined to

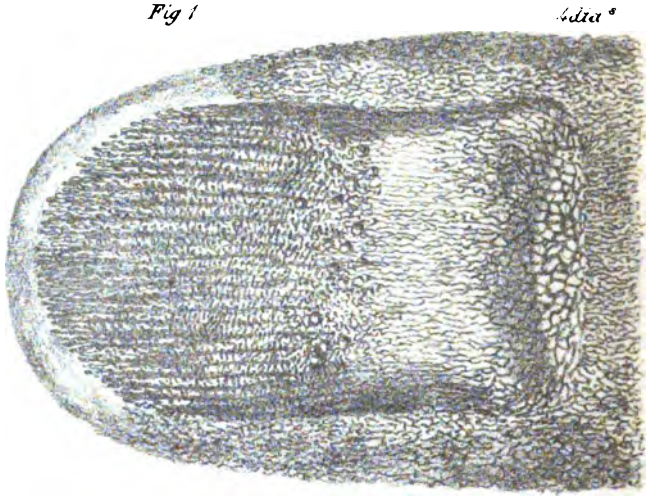
Fig 2.
9 diam.

Fig 3



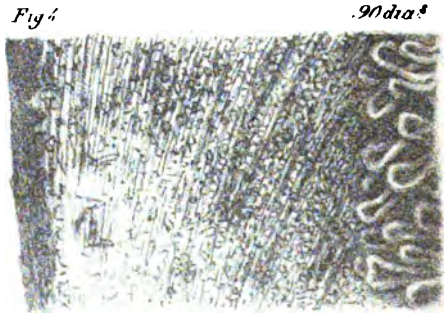
90 diam.

Fig 1



4 diam.

Fig 4



90 diam.

S W Leonard del. et lith.

E Carter imp.

think that the species will be found not to be so rare as has been supposed.

In the month of August and September last (1847), at Swanage, in the Isle of Purbeck, I met with no zoophyte so abundant, and so generally distributed on almost every kind of submarine object—Fuci, stones, Crustacea, and shells—as the *Notamia bursaria.* It appeared to live and flourish in from three to ten fathoms water, off several miles of the coast, as from Bournemouth to Swanage Bay, but to the southward of this point, as in Durlstone Bay, where the sea is rougher and the bottom more rocky, I did not meet with it. It has also been found, according to Dr. Johnston, on the coast of Devonshire, off the Isle of Wight, and off Essex; and I have been favoured with specimens of it, collected by Mr. Bowerbank, off Weymouth.

It appears, therefore, very strange that a species so abundant as this has proved to be in one locality, and which occurs at such widely distant points of the coast, as in Devonshire and Essex, should be so rare elsewhere, at least in sheltered and shallow bays. I would remark, however, that on a careful inspection of all the zoophytes collected at various times by dredging, in numerous different and very distant parts of the coasts of England and Wales, by Mr. Bowerbank, I did not observe among them any instance of the *Notamia bursaria,* excepting among those species collected by him last autumn at Weymouth. I am not aware that any foreign habitat has as yet been assigned for it. The conditions under which it occurs, present therefore an interesting subject for inquiry.*

The earliest notice, as I have before remarked, that we have of this *Bryozoon,* is in Ellis's Corallines, p. 41, Pl. 22, No. 8, and accompanying this notice is a figure designed with considerable elegance, and very correct, as far as the means of observation at that time allowed. Ellis's description runs thus:—"This most beautiful Pearl-coloured *Coralline* adheres by small tubes to fucuses, from whence it changes into flat cells; each single cell like the bracket of a shelf, broad at top, and narrow at bottom: these are placed back to back in pairs, one above another, on an extremely slender tube, that seems to run through the middle of the branches of the whole *Coralline.* The cells are open at top. Some of them have black spots in them,

* In the course of the present autumn I have met with the *Notamia bursaria* in great abundance off the East end of the Isle of Wight. It has also, I believe, been found at Southend and Ramsgate.

and from the top of many of them, a figure seems to issue out like a short tobacco-pipe; the small end of which seems to be inserted in the tube that passes through the middle of the whole. The cells in pairs are thought by some to have the appearance of the small pods of the *Shepherd's Purse*, by others, the shape of the seed-vessel of the herb Veronica or Speedwell."

The species, after several changes of appellation, received its present systematic name from Dr. Fleming. Whether this name should be retained or not, need not here be discussed, but it may be observed that as far as its derivation is concerned, we shall find that it is inapplicable, and that the appellation of *Epistomia* suggested by the same learned naturalist is equally inappropriate.

The polypidom of this *Bryozoon*, like those of most of its congeners, may be said to consist of a radical portion by which it is affixed to the objects upon which it grows, and of a celliferous portion, or branches upon which the polypes themselves are lodged. The radical portion in the present species consists of a central discoid body of a nearly circular form, and of branches radiating from the periphery of the disk, which thence exhibits something of the aspect of the body of an *Ophiura*. The radical tubes or branches, springing from the margin of the disk, are usually five or six in number, and they are given off at pretty regular distances apart; but besides these radical tubes, one or more celliferous branches are not unfrequently seen to arise immediately from the upper surface of the discoid portion.

The central disk, and the radical tubes arising from it, exhibit a similar structure, and are formed of a thick, firm, apparently horny envelope, containing a coarse granular matter of a yellowish white colour, and which in some portions of the tubes assumes the form of distinct irregularly globular masses of nearly uniform size. The central disk is subdivided into distinct compartments by septa of considerable thickness, and each radiating branch arises from one of these distinct compartments, so that there appears to be no communication between one radical branch and another. The radical branches give off, at irregular distances, secondary branches, which ultimately become celliferous. Each of these secondary branches, however, arises from a distinct compartment, as it were, of the tube from which it springs. This compartment is formed, like those of the central disk, by a thick septum, which shuts off the origin of the secondary branch from the main cavity of the primary one. The secondary

branches may usually be observed in all stages of development. Besides the dissepiments at the origin of each lateral branch of the radical tubes, the latter, especially towards their extremity, present transverse septa, and thus exhibit, in their mode of growth, a close resemblance to many *Confervæ*.

It will be difficult to make the more complicated conformation of the celliferous portion clear without reference to the figures.

The celliferous branches which constitute the principal part of the whole polypidom, arise, as has been said, either immediately from the discoid central body of the root, or from the radiating radical tubes or their lateral branches. They vary infinitely in number in different individuals, and differ also extremely in length,—some being nearly an inch long, but in the majority of individuals they are about half an inch in length when laid straight. When the zoophyte is living or recent, and unaltered by the fluid in which it may have been placed, the celliferous branches are always much curled, reminding one in their habit, thence derived, of the vernation of the fronds of many ferns, and the whole zoophyte from this acquires a peculiar and very elegant aspect. The branches divide dichotomously at tolerably regular intervals. They support the bracket-like polypiferous cells, which are placed in pairs, and with extreme regularity. It is to be observed, however, that at the bottom of every branch or at each bifurcation, the lowermost cell is single, or has none opposed to it on the other side of the rachis. This is uniformly the case. Above almost every pair of polypiferous cells, is to be noticed a pair of smaller cells, not unaptly compared by Ellis to the bowls of tobacco-pipes, with short stems. The larger or polypiferous cells will, in what follows, be termed "cells," and the smaller tobacco-pipe shaped organs will be termed "cups." It may then be stated that usually there is a cup above each cell, and this arrangement obtains throughout the polypidom, excepting immediately below each fork, where the cup is invariably absent above one of the cells of the pair from between which the fork springs. (See fig. passim).

This is the general arrangement of the cells and cups. It will be less easy to make clear the mode in which the cells and cups are mutually connected, and to render the description of this intelligible, it is necessary to consider each branch as presenting an anterior and a posterior aspect. The former of which is exhibited in fig. 2, *a*, and the latter in fig. 2, *b*.

The celliferous branches originate usually in a short trunk, similar in structure to the radical disk and its branches, and sometimes

at the extremity of the radiating tubes or their lateral branches. In either case, the formation of the polypiferous cells commences in the same way; the radical tube, forming the initial trunk of the celliferous branch, becomes dilated laterally to about twice its diameter, the dilated portion being separated from the rest by a transverse partition,—it being in fact one of the terminal joints or cells of the radical tube, such as I have mentioned above, expanded, (fig. 3). The walls of this dilated portion are thinner than the rest of the tube, as if the expansion were eccentric, and its cavity is divided into two by a longitudinal septum. In this way, what may be termed two initial cells are constituted, from which in continuous succession the whole of the rest of the branch appears to be formed. We now come to a more complicated part of the subject. It will be observed in fig. 3 that the whole branch appears to originate in two cells, marked *c*, *c''*, and farther, that the branch divides dichotomously at tolerably regular intervals, so that the number of secondary branches rapidly multiplies; but if the two primary cells *c*, *c''*, and those derived from them in *continuous* succession, were coloured red and blue respectively, it would be found that notwithstanding this multiplicity, the two original colours would be continued uninterruptedly to the extremities of two among the numerous branches; or in other words, it may be said that each primary cell is the origin of a distinct series of polypiferous cells and cups, that each of these series continues single to the last, and that each of them constitutes one half of the cells and cups on the branches upon which it occurs. It is clear, then, that at each bifurcation two fresh elements or series of cells are introduced, and it would be found, upon colouring each of these new series continuously throughout, that they also constitute continuous distinct elements of the polypidom, from their origin to the termination of two branches. It is to be borne in mind, however, that any two series or colours are never united in the same internode after the bifurcation of the one in which they first make their appearance.

It may then be said that the celliferous branch is compounded of numerous distinct series of cells, each forming a continuous chain from its origin to its termination at the ultimate extremity of the branch itself, and that at each bifurcation the due number of fresh series to complete the tale—viz. two—are introduced.

It remains to point out the mode in which these series of polypiferous cells originate, and are afterwards continued. The two primary series, or those marked *d* and *d''*, arise, apparently imme-

diately, from the two initial cells before described, in two cells usually smaller than the other polypiferous cells, and of a different form, and I have not yet been successful in seeing polypes in them. One of this primary pair, moreover, differs from every other cell in the branch, in its supporting a cup, and it is at this point that we first notice the appearance of the latter very curious organ. There is no communication, however, between the cup and the cell. The first two polypiferous cells being formed in this way, the series of which each of them is the commencement is thus continued. The primary cell which bears the cup is continuous by a contracted portion with the cell immediately above it (see fig. 3, *d*), which gives off from its superior and internal or axial angle a narrow tubular prolongation, which *above* the next pair of cells expands into the cell on the opposite side of the axis, and which constitutes one of the pair of cells next but one above; unless, as is frequently the case, the branch bifurcates immediately above the second pair of cells, in which case, the tubular prolongation of the cell is continued into the inferior or single cell at the base of one of the branches of the fork. The other primary cell, or that which forms the pair with the cup-bearing cell, sends up a prolongation from its superior and internal angle, which above the level of the first regular pair of cells expands into the alternate cell on the same side as itself, or one of those constituting the second pair of cells. The continuation of the series along the branch takes place in the same way, by each cell giving off a tubular prolongation from its superior and internal angle, which, *after* the first bifurcation, is always placed on the *anterior* aspect of the branch, and gives off or expands into a polypiferous cell at each alternate pair, and always at the same side of the axis in the same internode, and alternately on the other side in each fresh internode into which the series enters. We have thus from the primary pair of cells traced the origin of two series, each of which constitutes half of the two first branches into which the polypidom divides, and to each of which series one of the first pair of regular cells belongs, and one of the second pair, if there be two pairs before the first bifurcation. Supposing this to be the case, as in fig. 6, it will be seen that the primary cells are marked *a* and *a″*, the second pair of cells or the first regular pair *b* and *b″*, and the third pair *c* and *c″*. Now, of these four regular cells, two only are derived from the primary pair, viz. *b* from *a*, and *c″* from *a″*. It remains to account for the origin of *b″* and *c*. This will be seen, looking at fig. 6, to take place thus:—Above and behind the primary cell (*a″*) is placed a cup, which forms, as it

were, the fellow of the cup placed upon the primary cell (*a*). This cup, marked (*d*) in the figure, arises in a dilated ampulla, like those in the branches (to which I shall allude afterwards), on the same side of the axis as the cell *a*″. This ampulla or dilated portion, which must be considered in the light of a distinct cell or compartment of the axis, analogous to the other compartments in the radical disk and tubes before described, gives off laterally the stem of the cup, and is continued upwards into the cell *b*″, which, from its superior and internal angle, gives off a tubular prolongation, which passes on the *posterior* aspect of the branch till it reaches nearly the level of the upper border of the next pair of cells, where it expands either into two branches supporting cups, or into one such branch, and a wider one which expands into the lowermost or solitary cell of the other branch of the first fork, or the branch which forms the fellow to the one, the lowest cell of which was derived from the primary cell *b*, as before described. The remaining cell (*c*) also arises in a distinct compartment, like the former, and in this case, the arrangement, though apparently different, is actually the same. The new element of the polypidom, from whence the cell (*c*) is derived, originates in a narrow tube, also seen on the posterior aspect of the branch on the opposite side of the axis to the ampulla of the first cup, from which it is separated by a partition, and ascending on the posterior aspect and between the first regular pair of cells *b* and *b*″, when it reaches their upper border, it divides into or gives off two lateral branches (supporting the cups *e*, *e*) and is continued upwards into the cell (*c*), from the upper and internal border of which a tubular prolongation arises, which follows the same course as the similar processes from the other cells. I have been thus prolix in describing the mode of origin and continuation of the cells, as I think the structure I am describiug so imperfectly is extremely curious and deserving of close investigation. But the arrangement will be better understood by the inspection of the figures or of specimens than from any verbal description.

It may be sufficient to say, that corresponding to each fork, two fresh series of polypiferous cells are, as it were, intercalated into the polypidom, in a manner precisely similar to the two last described. I would also particularly draw attention to one point, which may perhaps, hereafter, serve to throw considerable light upon the real nature of the cups, and consequently upon the true nature and relations of the analogous organs in the other *Bryozoa*. It will be observed that each separate series of cells is connected at its origin with one or more cups, according to the number of pairs of cells on

the internode in which the series commences. The series, for instance, which begins with the single cup, as at fig. 5, *a*, presents its second cup at the first bifurcation and on the opposite side, so that the pair of cups exists, but they are not opposite each other, and as the series presents but one cell before the branch bifurcates, no other cup is formed in that series. For it is also to be remarked, that the tubular prolongation from the cells of each newly intercalated series, as long as the internode in which the series commences is continued without bifurcation, ascends on the *posterior* aspect of the branch, and gives off cups at each pair of cells immediately above that, of which the cell whence the tubular prolongation arises constitutes one; but that at the bifurcation, each series sends up its tubular prolongation on the anterior aspect of the branch, and never again affords origin to a cup. So that each series is connected with cups only at or near its origin, and is quite distinct, morphologically, from all the cups above the first bifurcation into which it enters. Thus, therefore, it may be said, that each series of polypiferous cells constitutes an individual or distinct organism, composed of a variable number of cells, and having near its inferior extremity or towards its origin, one, two, or three cups, which are either opposite each other in pairs, or not. I will not here enter into any long disquisition, as to the light which this curious relation between the cells and cups may throw upon their nature respectively, as in the present stage of inquiry, any speculation would, at least, as far as I can perceive, be premature and unsatisfactory. But the fact is curious, and taken in connexion with it I will remark, that although the polypiferous cells at the bottom of the branches, or at the bottom of each series, as it may be expressed, are always empty, and having performed their functions have become apparently useless; yet the cups belonging to the same series, and which consequently are placed below all these effete cells, retain their vital activity, and exhibit the same motions as those higher up the branch, and *seemingly* in more immediate connexion with active polypiferous cells. It would almost appear as if the polypiferous cells were to be regarded in the same light as the joints of a tape-worm, which as they maturate their ova are thrown off, and are replaced by a continued succession from above, as long as the head or nutrient organ of the aggregate animal retains its connexion with the source of nutrition. In the same way the polypiferous cells, as they are most probably the organs in which the ova are formed, appear after a time to discharge their contents, consisting not only of ova, but also of the polype itself, whose special function seems to have been

to provide for the formation of the ova, and of them alone; in which case is it not allowable to suppose that the nutrition of the whole aggregate animal, that is of each distinct series, is in some way connected with the more persistent nature of the cups?

This must, however, be left undecided, and I will proceed to describe more minutely the structure of the cups and cells and their contents. First, of the cups, which constitute the great peculiarity of this species, and which, as Dr. Johnston suggests, are clearly the analogues of the "bird's-head processes" in other *Bryozoa*, and with which, in fact, they exactly correspond in structure. The rudimentary cups (as they may be termed) in *Laomedea obliqua*, can hardly be deemed in any way analogous to the curious organs in question; at all events, they present nothing of the same structure, as might be supposed upon considering the absolute distinction of the classes of animals to which the *Campanulariadæ* and *Bryozoa* respectively belong. In form, as stated by Ellis, they resemble the bowl of a tobacco-pipe placed upon a short stem. The walls of the cup are tolerably thick, but brittle and opaque, from the abundance of calcareous matter contained in them, and which is present in greater quantity in them than in any other part of the polypidom. The mouth of the cup, which is directed upwards, has a sinuated margin, rising anteriorly into a sharp, curved beak, like that of the cuttle-fish, or hawk-billed turtle: when the earthy matter is dissolved away by acid, this beak is found to be formed principally of a horny substance, and it will be seen to be supported and rendered more firm by the anterior wall of the cup, from which it rises, being strengthened by the same material. The posterior edge of the cup is even and semicircular, and about midway between the front and back of the cup, the lateral margins rise up on each side into a small elevation, for the articulation of a movable beak or mandible. This beak, when viewed laterally, appears curved and sharp pointed, and when viewed *en face*, presents the form of an equilateral triangle, (fig. 4, *d*). It is formed of a firm, horny framework, the interior space of which is filled up with a membrane, in the centre of which, or rather nearer the apex of the triangle than its base, may be observed a small transparent spot, indicating the point of attachment of the tendon of the muscles by which the mandible is depressed or closed. The base of the triangle reaches across from one side of the cup to the other, and the mandible is articulated to the sides of the cup by the two angles of the base. A flexible membrane connects the base of the mandible to the posterior lip of the cup, and thus completely closes the orifice

when the mandible is depressed. The articulation, in fact, between the mandible and cup, bears a close resemblance to the joints of the *Articulata* in general. When partially closed, the point of the mandible comes close to the beak of the cup, but when completely depressed it lies within the latter, like the lower mandible of a parrot within the upper. The two beaks then would appear to constitute an admirable instrument of prehension. In the interior of the cup are contained two pairs of muscles, and a peculiar body of unknown nature. Of the muscles, one pair, and that much the larger, is for the purpose of depressing, and the other pair, for the purpose of elevating the mandible. The former, or occlusor muscles, form on each side of the cup a fan-shaped expansion; the broad part of the fan extending across the bottom of the cup, from before to behind. The muscles are composed of strong fibres, which are marked with distinct and regular transverse striæ, in all respects like those which characterize the voluntary muscles in the higher classes of animals. These fibres appear to form small bundles or fasciculi, each of which terminates abruptly in a narrow tendon, the union of all which tendons goes to constitute the common tendon of each muscle, and the conjoined tendons of the two ultimately constitute the tendon which is inserted into the mandible at the point above indicated: the function of this pair of muscles is evidently to close the mandible, slowly and with force. The other pair, or the elevator muscles, are placed in the back of the cup, from the posterior wall of which they arise and are inserted into the base of the mandible. Their position and size would indicate that their function is to open the cup by elevating the mandible, and that this motion is effected with rapidity, and without much power. This difference in the respective actions of the two pairs of muscles is shown very clearly in the motions of the mandible during life: it opens suddenly with a sort of snap, and is closed slowly. The bottom of the cup is entire.

The polype-cells are several times larger than the cups, and their walls are much thinner, in fact, sufficiently transparent to allow of the contents of the cell being pretty well seen without any preparation, even during the life of the animal. In shape they are inversely conical, and the outer and upper angle is usually produced into a prominent, sharp point. From the internal and upper angle arises the tubular prolongation going to form the next cell or cup, as the case may be, in succession. They are entirely closed at the top, contrary to what is stated in all previous notices, and, as has been shown, there

is no connexion whatever between the cell and the cup placed *immediately* above and behind it. The aperture of the cell is on the anterior face, and towards the upper margin; it is of a crescentic form, and placed obliquely as it were across the upper or internal angle of the cell, with the convexity of the curve directed upwards and inwards. The lips of the aperture are strengthened by thin bands of horny material, and under favourable circumstances, indications of short, muscular fibres, for the purpose of opening or closing the aperture, may be observed. This aperture, therefore, bears a strong resemblance to that of the cells in *Gemellaria loriculata*, figured by Dr. Van Beneden, and of many other *Bryozoa* belonging to the same sub-division.

The cell which I believe to be entire at the bottom, though closed only by a very delicate membrane, contains an ascidioid polype, any detailed description of which I am unable to give, and which would perhaps be superfluous, as the animal did not appear to present any peculiarity in which it differed from the typical form of that class of polypes, now so well known to us from the labours of Milne Edwards, Lister, Farre and Van Beneden. It has ten tentacula and no gizzard. Two sets of muscular fibres, at least, may be distinguished as appertaining to the polype. The most important of these are the retractor muscles, which, arising from the bottom of the cell, in the form of long, somewhat flattened, transversely striped, isolated fibres, about the $\frac{1}{10,000}$th of an inch in width, are inserted some of them at the base of the tentacles, and others lower down the body of the polype. Other muscles, which may perhaps, as suggested by Dr. Farre, be considered as the extensors, exist, in shorter transverse fibres, which, arising from the sides of the cup, are probably inserted into the sac in which the polype is contained. These fibres exhibit very distinctly a nucleus, nearly in the middle of their length, and the portion of the fibre between this nucleus and the wall of the cell is wider than the other portion, and in that wider portion only, and there rarely, have I been able to see transverse striæ.

With respect to the mode of development and the generation of this *Bryozoon*, I have little to offer, want of time not having allowed me to observe these points sufficiently in the living animal. But with respect to the mode of development of the cells and tubes at the extremities of the growing branches of the polypidom, it may be stated that the posterior and anterior connecting tubes of the cells and the two lateral cups, constitute, at the end of each branch, four

distinct buds, containing a fine granular matter, and appearing to be gradually developed into their respective complete forms, in the mode common to all hitherto observed *Bryozoa*, and so well depicted and described by Dr. Van Beneden in the instance of the *Laguncula* and others.

XX.—*Addendum to the Paper 'On the Application of Polarized Light in Microscopic Investigations.'* By M. S. Legg, Esq.

(Read December 22, 1847).

In the last part of the Society's Transactions, at p. 84, is given a description of the Nicol's prism, in which it is implied that the complete separation of the two images is effected by means of glass employed in its construction, and as this (as well as the explanation of the fig. 3, Pl. 12) would convey an erroneous impression, I am desirous of adding a more ample description, and at the same time of acknowledging my obligations to the late Mr. Sanderson, of Edinburgh, for information, and to Mr. Darker, of Lambeth, for his kindness in pointing out to me the details in the construction of the prism.

"This instrument is described by the inventor in Jameson's Edin. Phil. Journal (vol. vi. p. 83), and consists of a rhomb of Iceland spar, in the proportion of 1·4 inch in length, and about ·48 inch in breadth and thickness, divided into two equal portions (see fig. 3, Pl. 12) in a plane passing through the acute lateral angles, and nearly touching the obtuse solid angles. The sectional plane of each of these halves must be carefully polished, and the portions cemented firmly with Canada balsam, so as to form a rhomb similar to what it was before its division: by this arrangement the ordinary and extraordinary rays are so separated that only one of them is transmitted; the cause of this great divergence of the rays is considered to be owing to the action of the Canada balsam, the refractive index of which (1·549) is that between the ordinary (1·6543) and the extraordinary (1·4833) refraction of calcareous spar, and which will change the direction of both rays in an opposite manner before they enter the posterior half of the combination."

In finishing these prisms, it is usual to cement a piece of thin glass to that face of the prism which is most frequently exposed to dust, to protect the spar from scratches; but some double-image prisms, particularly those of moderately dividing power (called Biot's rhombs), are composed of one half glass and the other half spar.

XXI. — *Observations on the Anguinaria spatulata.* By George Busk, Esq., F.L.S., &c.

(Read January 26, 1848).

The very remarkable *Bryozoon*, known under the name of *Anguinaria spatulata*, or the "Snake coralline" of Ellis, is stated by Dr. Johnston to be "not common." I was, therefore, in respect of it, as of the *Notamia bursaria*, fortunate in meeting with this species in very great abundance and perfection, and in the same locality as the former. It is parasitical upon Fuci, and appears to flourish in from three- to ten-fathom water, and is not unfrequently associated with other polypes on the same plant. An instance of this kind is shown in fig. 1, Pl. 26. It is here associated with *Campanularia integra*, and in other specimens I have seen it growing together with *Laomedea obliqua* and other Sertularians. Its character, as given in Dr. Johnston's work, is as follows:—

"Polype cells spathulate, erect, scattered, with a lateral aperture near the apex; originating from a creeping fistular subcalcareous fibre, adnate to a foreign base.—Polypes ascidian." This character, I think it will be seen, is incorrect in several particulars, which it is partly the object of this paper to point out.

The *Bryozoon*, as a whole, consists like all its congeners of two distinct portions, one, usually termed the radical, and another, which constitutes the proper polype cells. In the present instance, the arrangement of these parts is in some respects very peculiar and curious, but it will be found upon strict examination to accord accurately with the universal type. The origin, or base, as it may be termed, of the zoophyte is a more or less rounded disk of small size, probably divided into compartments as in the *Notamia*, from each of which arises a primary radical branch, in this species very short; these primary radical branches or tubes are directly continued into a polype cell, but the cavities of the tube and cell are not continuous, being separated by a distinct dissepiment (fig. 7), so that the

coarsely granular contents of the radical tube have no communication with the polype cell. The polype cell is at first continued in a line with the radical tube from which it originates, but soon turns up at a right angle and stands erect upon the object on which the *Bryozoon* is growing. After ascending in a nearly straight line for a certain distance it curves with a gentle sweep, and terminates in a slightly expanded extremity, at the apex of which, and not at the side, is the opening through which the polype protrudes. The continuation of the radical portion of the zoophyte, or of that creeping fibre, as it appears, which is adnate to the foreign base, is effected by the formation, at the angle where the polype cell turns up, of a bud containing granular matter, which becomes a narrow tube, in all respects similar to the primary radical tube, and which, like it, after running a short distance, terminates in a second polype cell resembling the first, and so on continuously, to an uncertain number. The growth of the polype cell appears to precede in some degree that of the radical tube continuous from it, but it is not necessary that the growth of the former should be completed before the latter makes its appearance. The development of these two parts seems to be carried on in the usual way; viz., first, in the appearance of a rounded bud filled with granular matter, which gradually increases in length, and the contents of which are finally moulded or resolved into the proper contents of the cell, of which the bud constitutes the origin. In some cases more than one bud of a radical tube arises at the angle of the polype cell, and in this way arise the apparent branches of the creeping stem. The walls of the radical tubes and of the polype cells consist of a thin transparent horny material, which is insoluble in weak acids, and strengthened or rendered rigid, except in one part, by the deposit of calcareous matter. In the radical tubes, and on the dorsal or upper surface of the dilated extremity of the polype cell (fig. 4), this earthy matter is deposited in the form of minute angular or rounded particles, presenting faint traces of a linear arrangement, but in the main body of the polype cell, or the upright portion, the calcareous material is arranged in beautifully regular rings, giving that part of the zoophyte a peculiarly elegant appearance under the microscope. This calcareous ingredient is sufficiently abundant to render the contents of the radical tubes and polype cells indistinct, and to obtain a satisfactory view of these parts it is necessary to remove the earthy matter by some weak acid. When this is done it will be found that the contents of the radical portion are, as before mentioned, coarsely granular, and the wall rather thicker than those of the proper polype cell. The latter con-

tains an ascidian polype, which has about twelve tentacula and no gizzard. The polype, so far as I have observed, is always lodged in the upright portion of the cell, but the long retractor muscular fibres arise near the commencement of the horizontal portion of the cell, and from its upper wall, nearly at one point. They consequently turn abruptly round the angle formed by the rising up of the cell, and passing chiefly on the side (the anterior) of the body of the polype, are inserted, some towards its inferior part, and some apparently near the base of the tentacula, as in other polypes of this class (fig. 7). The muscular fibres consequently are of great proportionate length; they are distinctly marked with transverse striæ, and appear to me to be constituted of a delicate diaphanous tube, or sarcolemma, containing the more solid, contractile, sarcous particles. I am led to this conclusion, from observing here and there in some of the fibres, spaces in which the fibre is very transparent and unmarked with striæ, as if a tube were stretched and two portions of its contents drawn apart within it (fig. 8). The tentacula are from ten to twelve in number; they are very long, and have a series of spinous projections, as remarked, I believe, by Mr. Lister, on their outer side. The resemblance of the terminal expanded part of the polype cell to the head of a snake is very striking, and in fact, of the whole cell to the body of a serpent, and thence has arisen its very appropriate generic name. It would appear, from the descriptions heretofore given of this zoophyte, that the form and situation of the aperture have not been rightly apprehended; and as in the systematic arrangement of this class, these particulars will be found of the first importance, it is to this part I would direct attention. The aperture is terminal, and in form crescentic (fig 2), the lower lip being formed of, or strengthened by a cartilaginous or horny half-ring, very nearly resembling a horseshoe in form, and which constitutes the movable part of the rim of the orifice, and to which are attached two pairs of muscles, one for the closure, and the other for the opening of the aperture. I should have stated, in speaking of the structure of the walls of the polype cell, that the upper or dorsal portions only of the expanded extremity were strengthened by calcareous matter, the lower side being filled up by a thin flexible membrane, attached in front to the cartilage of the lower lip of the aperture, and which by its flexibility, allows the latter to be moved with ease. This membranous expansion may be likened to the bag of the pelican's beak, and like it, seems sometimes to be used as a receptacle for food, at all events, it will occasionally be found to contain numbers of *Naviculæ*

and other Infusoria. The muscles which move the horseshoe-shaped cartilage constitute two pairs, one superior, the occlusors, which are attached by a slender tendon to the upper angle of the expanded base of the horns of the crescentic cartilage, and the other, the inferior or dilators, which are inserted beneath the inferior angle of the same base. These muscles, like the retractors of the polype, are marked with transverse striæ. The expanded portion of the cell, besides these special muscles of the aperture, contains other muscular fibres, in all respects resembling those described by Dr. Farre, as conducing to the extrusion of the polype in *Bowerbankia*, and which are also very distinct in the *Notamia*, but which in the present instance would seem to have for their chief function, the drawing up or corrugation of the membranous portion of the polype cell. These muscular fibres have a distinct central nucleus or thicker portion, as is the case in the analogous muscles in the other cases just cited. It will thus be seen that, in the important particular of the aperture, the received statement that it is "inferior subterminal, oval, and with plain margins," is in every particular incorrect. It is on the contrary terminal, crescentic, and one half of its margin constituted of a movable horny lip, the other half formed by the calcareous wall of the polype cell, resembling in fact, the aperture in *Gemellaria*, *Notamia*, and others, in which part of the wall of the cell near the aperture is filled up by a flexible membrane, attached probably in all cases, though this has not yet been shown, to a movable horny lip with appropriate muscles. This *Bryozoon*, therefore, together with, at all events, *Gemellaria loricata* and *Notamia bursaria*, must be removed from the family *Eucratiadæ* of Dr. Johnston, or the characters of that family must be modified, as respects the situation and construction of the aperture of the cell.

I would direct attention to an appearance not unfrequent in the polype cells, as if they had been repaired after being broken. This appearance is seen in figs. 5 and 6.

XXII.—*On an Improvement in the Stage of the Microscope.* By M. S. Legg, Esq.

(Read Jan. 26, 1848).

It may be in the recollection of many members of the Society, that last year our attention was directed to a useful mode of manipulation, in a paper by John Anthony, Esq., "On certain appearances observable in *Navicula*, from the Humber, by means of Oblique Transmitted Light,"* by which certain markings existing in various objects may be more readily observed: this communication has doubtless had the effect of recalling the attention of microscopists to a most eligible means of detecting lined structures. The importance of employing oblique illumination, and the consequent necessity of readily turning the object so as to place it at right angles to its former position, and present it in an opposite direction to the light, is sufficiently obvious, as, I trust, to justify the introduction of an improvement in the stage of the microscope by which these desiderata may be accomplished.

In the present arrangement of stages to microscopes as far as I have as yet observed, the revolving-plate, when present, is placed *above* the vertical and horizontal movements, the consequence is that unless the stage-actions be brought to certain fixed points (in which case the object must be adjusted to the field of the microscope by the hand) the object is sure to be lost to the field of view directly the revolving-plate is turned upon its axis, and if the adjustment be at all out of place, the object will be found to describe an orbit round the centre of the revolving-plate, which will increase in proportion to the eccentricity of the adjustment.

The above difficulties occurred to me, on a recent occasion in examining with a friend a specimen of *Navicula*, sent from America by Professor Bailey, under a high power, and although the object, when turned one quarter of a circle, was readjusted under a lower power, it was with difficulty found again.

* In Annual Report, 1847, p. 17.

Under these circumstances, it appeared to me that these difficulties might be overcome by a different arrangement of the parts of the stage, without at the same time detracting in any great degree from the conveniences and appliances existing in the stages at present employed; this I propose to effect by changing the position of the revolving-plate, and placing it *below instead of above the actions of the stage;* by adopting this principle it is evident *that if the centre of the revolving-plate be a fixed point coinciding exactly with the axis of the microscope,* the object under examination must remain in the field of view during an entire revolution, however eccentric the adjustments may be: in confirmation of this principle I was induced to construct the rough model which you see on the table, and my views have since been admirably carried out by Messrs. Smith and Beck, in adapting a new stage to my instrument.

The principal feature then, in this improvement, consists in fitting the revolving apparatus immediately upon the foundation-plate of the stage by means of a strong dovetailed or conical ring, working firmly but freely in the foundation-plate; when in use it may be turned by hand, or if great nicety be required, an endless screw may be fitted, acting upon the ring, and connected with a milled head placed at the side of the stage; upon this ring is fixed a plate upon which the stage-actions are adapted; the adjustments are effected by two milled heads on each side of the stage: the lateral motion consists of a screw working in a collar connected with the sliding-plate, and the vertical action is effected by means of a pinion fixed in the sliding-plate and acting upon a rack on the under side of the top or object-plate; the whole is so constructed that it will traverse the entire circle, and pass under the arm of the microscope without impediment. It may be objected as unnecessary that the stage and its appurtenances should revolve entirely round the circle, and perhaps a partial revolution would be sufficient for many objects, in which case a larger and more commodious stage may be constructed, but my principal object in proposing an entire revolution is to prove the efficacy of the principle, as well as to adapt it in many cases where it may be found advantageous, as, for example, in the examination of opaque objects illuminated by a side light, when it is desirable to cast a shadow in an opposite direction, which may be done by turning the stage and object round instead of changing the light: it will also be useful in examining certain objects in polarized light, when it is wished to place either the neutral or positive axis of a crystal to coincide with the plane of vibration.

These arrangements afford the usual large aperture for throwing a light from the mirror upon a Lieberkuhn, and do not in any way interfere with the ordinary diaphragm or the adaptation of the achromatic condenser.

In applying this principle to the stages of microscopes much will depend on the taste of the microscopist, and the ingenuity of the workman, but the chief points to be attended to are, the making the centre of the revolving-plate to coincide with the axis of the instrument, and placing the adjustments above the revolving-plate.

It will be found by experiment that an object placed in the centre of the field under one object-glass will not be exactly so when another is employed; this arises from the well-known difficulty of accurately centreing the object-glasses, and consequently the almost impossibility of making the optical and mechanical centres exactly the same. I may state, however, that the old stage of my microscope has been altered in accordance with the principle above laid down, and I find that under a power of 500 diameters an object is retained in the field, though not in the centre, during the three-fourths of a revolution to which the stage is limited (an approximation to mechanical truth sufciently close) that the slightest touch of the adjustments will bring the object again to the centre.

EXPLANATION OF PLATE XXVII.

Fig. 1. Represents the foundation-plate with the dovetailed or conical ring, it is drawn in perspective to show how much the ring is raised that the adjusting parts (or milled heads) may pass clearly when the stage is revolved.

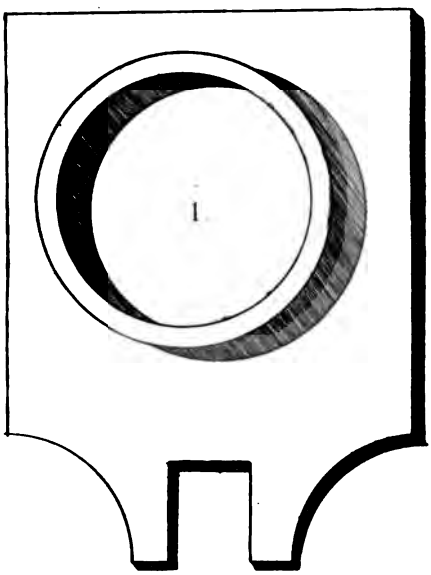
Fig. 2. The revolving-plate (which is fitted to the ring) upon which the movements of the stage are adapted; upon it are fastened the dovetails (*a*) in which the lateral motion works, and the screw (*b*) by which it is moved.

Fig. 3. The lateral sliding-plate; the lower part forms a collar (*c*) in which the screw of fig. 2 works, on the upper part is a pinion (*d*) by which the vertical plate is moved up and down.

Fig. 4. The vertical-plate upon which the object is placed. On the under side is fixed a rack corresponding to the pinion in fig. 3, the upper side is fitted with two clamps sliding in dovetailed grooves; the inner parts of the clamps are hollowed out to admit the light freely from the mirror when the Lieberkuhn is in use.

(The extent of the lateral and vertical actions is about one inch each way).

Fig. 5. A sketch of the stage in its finished state; the arrow indicates the axis of the body of the microscope; *a*, the pin to carry the forceps; *b*, a knob for turning the revolving-plate; *c*, the ring immediately upon the foundation-plate.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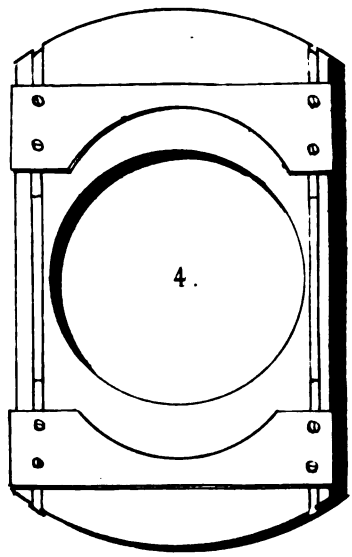
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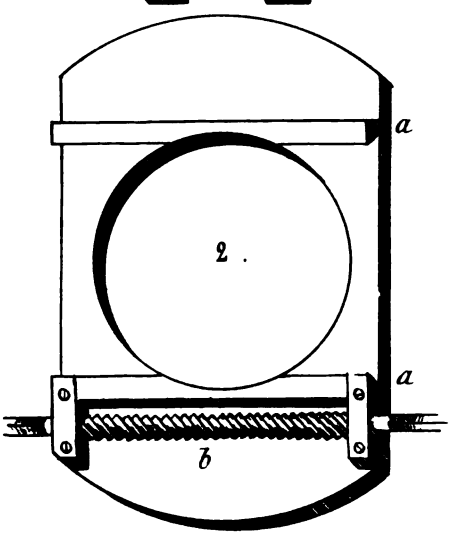
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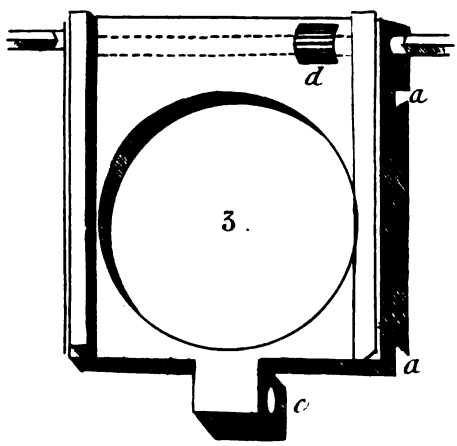
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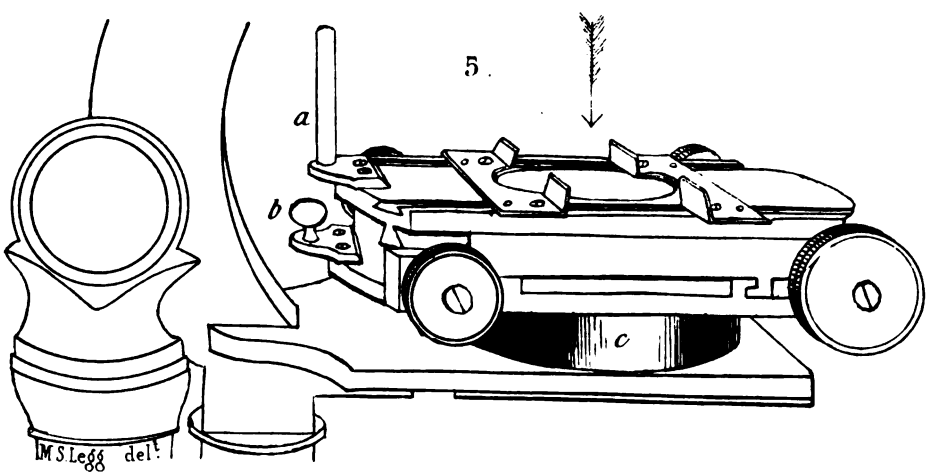
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XXIII. — *On a New Medium for mounting Organic Substances as Permanent Objects for Microscopic Inspection.* By ROBERT WARINGTON, Esq.

(Read March 29, 1848).

THE want of some non-volatile fluid for the purpose of mounting organic objects permanently for microscopic investigation must have been felt by all parties accustomed to the practical manipulation of such matters; and it is with the view of affording some assistance to the working microscopist in this direction, that I am induced to lay the present brief communication before the Society.

In making these remarks, I allude more particularly to such organic objects as occur in a wet state, or contain water in their structure or substance, and which, if got rid of by exsiccation, would destroy the configuration and appearance of the subject, as must be the case with many confervoid plants, *Desmideæ*, and many delicate animal or vegetable preparations, as well as in various other cases, too numerous to enumerate.

The fluid, which I have to bring under the notice of the members of the Society, is generally termed Glycerine, or Oxide of Glycerule; it is the sweet principle, as its name implies, of all oils and fats, which consist of this compound in union with the fatty and oily acids: when therefore these are separated, by causing them to combine with any base for which they may have a stronger affinity, as in the processes for making soaps and emplastra, the Glycerine is set free, and as in these operations it is always necessary that water should be present to effect the required decomposition, this agent holds the sweet principle in solution, and may be readily separated when the process is perfected.

Having had occasion to apply the fluid, in consequence of its peculiar properties, to the purposes of preserving animal and vegetable substances on the large scale, I was induced to try its application to effect the desideratum already alluded to.

The method I have adopted in the employment of Glycerine, is simply to mount the object in the manner it is usually performed when spirit of wine or creosote water is used as a medium, and having covered the immersed object with the thin glass and removed all excess of liquid, to cement the margin with a coating of shell-lac varnish; the one I usually employ consists of the ordinary black sealing-wax dissolved in rectified spirit of wine. Care must be taken during this operation to maintain the slider in a flat position until the varnish has become dry from the evaporation of the spirit, and also until a sufficient number of coatings or layers of the varnish have been applied to render the subject perfectly secure and prevent any escape of the fluid. Gold-size or copal dissolved in oil of lavender may be employed to effect the same purpose, and the second and third coatings may, with advantage, consist of either of these, which yield a tough varnish above the lac, which is otherwise liable to become brittle. The Glycerine may be used in its concentrated treacly state, or it may be diluted with distilled water to any required extent, according to the object of the operator and the subject to be mounted; if there be extremely fine markings on the subject it is better to add about four or five times its volume of water, as otherwise the thick fluid may prevent these from being so sharply defined as may be desired. I have had a number of slides of *Desmideæ* which have been mounted from four to ten months by this means, and they have kept excellently. The Glycerine may also be used with the addition of a small portion of culinary salt, corrosive sublimate, creosote or spirit of wine, if considered desirable.

While on this subject, I may, perhaps, be allowed to describe shortly to the Society the method I have adopted for using castor oil as a medium for mounting certain classes of objects; this method was described in a paper, read before the Chemical Society, in January, 1844,* entitled 'A means of preserving the Crystals of Salts as permanent objects for microscopic investigation;' and as I have been frequently questioned on this subject by members of the Microscopical Society, I hope its brief abstract may not be deemed out of place here.

The object required to be mounted is placed on the slider in its dry state, or deposited wet and allowed to dry, or if in solution, a drop of the liquid is to be placed on the slip of glass and allowed to crystallize by spontaneous evaporation; in the latter case I prefer

* 'Proceedings and Memoirs of the Chemical Society,' vol. ii. p. 71.

taking a drop of a warm saturated solution of the salt required, and when a good group of well-defined crystals has been obtained, to break through the marginal ring of crystalline deposit with a small point of wood, and carefully conduct off the uncrystallized portion or mother liquor to the extremity of the slide, at the same time placing it in a vertical position to drain until it is dry. A small quantity of castor oil is to be next carefully dropped on the subject and guided over the field with the point of a needle; in this way it readily displaces the air and occupies the most minute cavities. After a short time the upper glass is to be placed on the surface, taking care to lower it gradually so as to exclude the air; if the field is too full of oil the excess may be removed by a small piece of bibulous paper, and if, on the contrary, sufficient oil has not been used, an additional portion can be readily introduced, by the capillary action, between the glasses. I mention these points of practical manipulation because on them the success of the operation may often depend, as it must be evident that in the first case, the excess would prevent the cell from being properly sealed by the varnish, and in the latter, it would be drawn into the field and the whole operation spoiled. The shell-lac varnish is then to be used as the cementing medium in the same way as has been described, and with the same precautions. I may also observe, that this varnish cannot be replaced by either of the others, as it is actually necessary (and this should always be borne in mind) that there should exist no affinity between the fluid in the cell and the varnish used to seal it permanently. Hundreds of excellent objects have been lost from this cause, and much valuable time and labour thrown away.

The reason why oil was selected for this purpose arose from its want of action on most crystalline salts, many of which could not be preserved uninjured in any other medium. Castor oil was chosen in consequence of its not depositing a crystalline stearine by reduction of temperature, as is the case with most oils, and even in some specimens of this material, it therefore requires to be carefully examined in this respect before it is employed.

In the same year I used this medium as a mounting fluid for minute *Fungi* and *Pediculi*, with complete success, and exhibited them to numerous microscopic friends, by some of whom it has also been since employed with entire satisfaction.

XXIV.—*On Micrometers.* By George Jackson, Esq.

(Read November 24, 1847).

It is often desirable in microscopical investigations to have a ready means of ascertaining the dimensions of the objects we are examining; and this want was felt by microscopists at a very early period. Leuwenhoeck, the father of microscopical discovery, selected minute grains of sand as nearly alike as possible; and, arranging them in a line, counted the number which occupied the space of an inch. By comparing the subjects of his examination with these, he was enabled to form a rough estimate of their bulk.

This was a rude contrivance, and suited to the infancy of the microscope; but one on a similar principle, although rather more refined in practice, has been recently proposed by a distinguished German botanist, and an enthusiastic advocate of microscopical research. Schlegel recommends that we should take as our standard the blood-corpuscles of some common animal, and estimate the size of other bodies by comparison with them.

Leaving the history of micrometry as a subject more curious than useful, we will proceed to the methods at present practised.

Lines can be ruled with a diamond one thousand to the inch, or even finer, with considerable accuracy; and the idea would naturally occur to any one that were an object laid on a slip of glass so divided, it could be measured as we measure larger bodies with a rule. This, however, except with a low power, is quite impracticable; for the focus of a good microscope is so precise, that the plane in which objects can be distinctly defined is almost a mathematical one, which cannot be occupied by two bodies at the same time: and besides, if the object be immersed in a fluid, as is generally the case, the lines become filled with it, and are thus rendered invisible.

The measuring of the object itself being then impossible, let us turn our attention to its magnified image: and here a variety of methods have suggested themselves to microscopists.

When Mr. Lister undertook, in conjunction with Dr. Hodgkin, to measure the human blood-discs, and to determine which of the very discordant statements of anatomists was most entitled to confidence, he used the following method.

By means of the camera lucida he first made a sketch of the blood-discs; and then, without altering the distance of the paper, or the optical arrangements of the microscope, he placed a slip of ruled glass on the stage in place of the object, sketched it on the paper, and used it as a scale to measure the drawing that he had previously made. The object and the micrometer being both magnified to the same extent, their images will necessarily bear the same relation to each other as the bodies themselves. The method is, therefore, correct in principle, and should always be practised when drawings are made, as preferable to the common mode of merely stating the magnifying power used.

Micrometric measurements then are made by comparing the *magnified image* of an object with the *similarly magnified image* of a scale of known dimensions; and we have next to consider the readiest and simplest means by which this may be effected; taking care to attain the utmost accuracy that the subject admits.

Although Mr. Lister's mode is capable of a good deal of precision, yet, when a drawing is not otherwise required, it is not the most ready method that has been contrived. If a micrometer be placed in the focus of the eye-glass, it will serve as a common measure by which an object on the stage, and another micrometer in the same situation, may be compared: and it has this among other advantages, that when we have ascertained with each of our object-glasses the relation which exists between the two micrometers, that on the stage may be dispensed with.

The micrometer generally used with astronomical telescopes consists of two parallel wires (or spider's webs), one fixed, and the other movable by means of a screw, the head of which is divided into one hundred parts. This, with a simple contrivance for reading the number of turns made, enables us to ascertain the distance of the wires to the hundredth of the turn of the screw: and, as the latter has commonly about one hundred threads to the inch, it should measure the magnified image of an object to the ten-thousandth of an inch.

With an object-glass of one-eighth of an inch focus, and a body of the usual length, the image will be amplified about eighty times, exclusive of the power of the eye-piece; and, therefore, a quantity as

small as the eight-hundred-thousandth of an inch should be appreciable by such an instrument. But can anything like this precision be attained in practice?

When Mr. Ross was constructing his beautiful engine for dividing circles, he found that he could not ascertain the *position* of a line nearer than to the eighty-thousandth of an inch, even with achromatic glasses, and the micrometer just described: showing that such a micrometer is at least ten times as delicate as can be rendered available to the microscope.

Without entering into the optical reasons why the *position* of a line can be determined to a greater degree of accuracy than the *diameter* of an object having sensible thickness, we will proceed to the method of finding the value of the divisions of the eye-piece micrometer with a particular object-glass. In the telescope this is effected by noticing the number of seconds which a star occupies in passing from wire to wire when the latter are placed at a certain distance apart; and a better method can scarcely be desired. The diurnal motion of the earth is perfectly equable, and that of the clock or chronometer by which it is measured may also be considered so for short intervals of time; the errors therefore are merely those of observation; which, by sufficient repetition, may be reduced to an insensible quantity.

In the microscope the case is widely different; there is no such *perfect* foundation to build on; for we can only assign a value to the eye-piece micrometer by comparing it with one on the stage; and, if the latter be accurate to the twenty-thousandth of an inch, it is the utmost that can be expected. By not depending on a single division, but taking an average of several, the error may possibly be diminished to the half of that quantity; and we shall then have very nearly reached the limits of optical as well as mechanical accuracy; for although the position of a line may, by very careful observation, be ascertained to the eighty-thousandth of an inch, the diameter of a body can hardly be measured nearer than the forty-thousandth, if so near. Any means then by which this degree of accuracy can be attained will be quite sufficient for our purpose, all beyond being useless.

A slip of glass placed in the focus of the eye-glass can be used with the divisions sufficiently fine to have the value of the ten-thousandth of an inch with the quarter-inch object-glass, and the twenty-thousandth with the eighth; and at the same time the half, or even the quarter, of a division may be estimated; thus affording the means of attaining all the accuracy that is really available. It may therefore entirely supersede the more complicated and expensive

screw-micrometer, being much handier to use, and not liable to derangement in inexperienced hands.

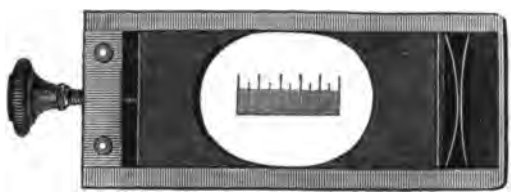
The next subject for consideration is the kind of eye-piece best suited to microscopic measurement.

The positive eye-piece was constructed by Ramsden especially for micrometric use, and Mr. Ross applies it to the micrometers that he furnishes to his microscopes. Mr. Smith and Mr. Powel, following Mr. Tully, place the micrometer in the negative eye-piece in the situation of the stop.

Each of these plans has its peculiar advantages. The positive eye-piece gives the best view of the micrometer, the negative of the object. The former is quite free from distortion, even to the edges of the field, but the object is slightly coloured. The latter is free from colour, but is slightly distorted at the edges: in the centre of the field, however, to the extent of half its diameter, there is no perceptible distortion; and the clearness of the definition gives a precision to the measurement which is very satisfactory. For this reason I give it the preference.

I will now proceed to describe the micrometer which I laid before the Society at a former meeting.

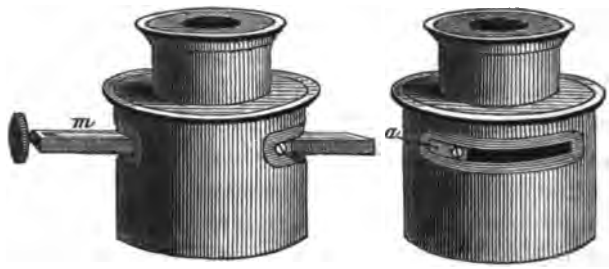
Short bold lines are ruled on a piece of glass; and, to facilitate counting, the fifth is drawn longer, and the tenth still longer, as in the common rule. Very finely levigated plumbago is rubbed into the lines to render them visible; and they are covered with a piece of thin glass, cemented by Canada-balsam, to secure the plumbago from being wiped out. The slip of glass, thus prepared, is placed in a thin brass frame so that it may slide freely; and is acted on at one end by a pushing-screw, and at the other by a slight spring (fig. 1).



(Fig. 1).

Slits are cut in the negative eye-piece on each side (fig. 2), so that the brass frame may be pressed across the field in the focus of the eye-glass; the cell of which should have a longer screw than usual to admit of adjustment for different eyes. The brass frame is retained

in its place by a spring within the tube of the eye-piece; and, in using it, the object is brought to the centre of the field by



(Fig. 2).

the stage movements, and the coincidence between one side of it and one of the long lines is made with great accuracy by means of the small pushing-screw that moves the slip of glass. The divisions are then read off as easily as the inches and tenths on a common rule. The operation indeed is nothing more than the laying a rule across the body to be measured; and it matters not whether the object be transparent or opaque, mounted or not mounted; if its edges can be distinctly seen its diameter can be taken.

Previously, however, to using the micrometer, the value of the divisions should be ascertained with each object-glass; the mode of doing which I will explain more fully.

Lay a slip of ruled glass on the stage, and, having turned the eye-piece so that the lines on the two glasses are parallel, read off the number of divisions in the eye-piece which cover one on the stage. Repeat this process with different portions of the stage-micrometer, and, if there be any difference, take the mean. Suppose the hundredth of an inch on the stage requires eighteen divisions in the eye-piece to cover it; it is quite plain that an inch would require eighteen hundred, and an object which occupied nine of these divisions would measure the two-hundredth of an inch. This is the common mode of expressing microscopical measurements; but I am of opinion that a decimal notation would be preferable if universally adopted. Take the instance supposed, and let the microscope be furnished with a draw-tube marked on the side with inches and tenths. By drawing this out a short distance the image of the stage micrometer may be expanded until one division is covered by twenty in the eye-piece. These will then have the value of two-thousandths of

an inch, and the object which before measured nine will then measure ten; which, divided by 2000 gives the decimal fraction ,005.

Enter in a table the length to which the tube is drawn out, and the number of divisions on the eye-piece micrometer equivalent to an inch on the stage; and any measurements afterwards taken with that micrometer and object-glass may, by a short process of mental arithmetic, be reduced to the decimal parts of an inch, if not actually observed in them.

In ascertaining the value of the micrometer with a deep object-glass the hundredth of an inch on the stage will occupy too much of the field: the two-hundredth or five-hundredth should then be used, and the number of divisions corresponding to that quantity be multiplied by two hundred or five hundred, as the case may be.

The micrometer should not be fitted into too deep an eye-piece, for it is essential to preserve clear definition. The middle eye-piece of the London-made instruments is for most purposes the best, provided the object-glasses be of the first quality; otherwise the eye-piece of lowest power answers better. The lens above the micrometer should not be of shorter focus than three-quarters of an inch, even with the best object-glasses.

Micrometers have generally been ruled in squares; but when fine they are with difficulty counted, and in no case possess an advantage over the one above described; for it is obvious that dimensions may be taken in any direction by merely turning the eye-piece.

It is almost needless to remark that this is not injured by the slits cut in the tube; consequently an additional one is not necessary; and the expense is confined to the slip of ruled glass and the fittings. The means, therefore, of measuring minute objects with the utmost accuracy, can be applied to any compound microscope for a few shillings.

In conclusion, I would observe that the fine focal adjustment made by moving the object-glass alone, and thus altering the distance between it and the eye-piece, would destroy the *perfection* of micrometry were it otherwise attainable; and the adjustment for thickness of glass is a quantity by no means to be neglected. The value of the micrometer should be found with the object-glass, set both for uncovered and covered objects;* and, during this operation the screw

* The draw-tube should be adjusted so as to give the same value in both cases, and the distance to which it is drawn out should be entered in the table: it will then be easy to set it so as to give correct results in any state of the object-glass.

of the focal fine adjustment should be placed about midway between the two extremes.

The only novelty in this communication is the pushing-screw, which acts as a fine adjustment in bringing a line on the micrometer to coincide with the edge of the object to be measured. This I exhibited to the Society at a former meeting, and the president afterwards suggested that I should prepare a written description of it, that it might, if the council thought fit, be published in the 'Transactions.'

I have found so many working microscopists without any clear ideas on the subject, that I have gone much further into it than would have been necessary merely to describe this little contrivance: and I have done it in the hope that, although the details will to many appear tedious, there are some few to whom they may be of service.

XXV.—*Observations on the Anatomy of the Skin of a Species of Muræna.* By ANDREW CLARK, M.D. Communicated by J. E. GRAY, Esq.

(Read March 29, 1848).

THE following anatomical details are based chiefly on examinations of the skin of a species of *Muræna;* but as the skins of several allied species were likewise examined, and as the points of difference were few and of degree only, the present account of the anatomy of the skin may, in as far as it extends, be considered typical of such members of the eel tribe as are devoid of dermal appendages in the form of bones or scales.

The thickness of the skin in these animals, its density, and the presence of much oily matter, render any minute examination of it extremely difficult. By macerating the skin, however, sometimes in ammonia, sometimes in ether or potass, these difficulties were greatly lessened, and the study of its histological elements rendered comparatively easy.

The skin of the *Muræna* may, in a philosophical sense, be considered a mediate phase of compound textural development, connecting the mucous membrane on the one hand with the less highly organized tegumentary membrane on the other, and affording an illustration of one of the many gradations of form by which these structures merge into each other.

The only essential elements in the composition of the mucous tissue in its most comprehensive signification are the primary, germinal, or basement membrane, and the layer or layers of epithelial cells on its free surface, the conjoint inflections of which constitute the follicles or glands.

These elements undergo various modifications, and receive also certain appendages, according to the position in which the tissue is found and the particular end which it is destined to fulfil in the economy.

To the primary membrane and its epithelium are added on its deep surface various forms of areolar tissue and capillaries; and, with the

modifications of the former the modifications of the latter sometimes correspond, but not always, and never necessarily. The areolar or filamentous tissue is subservient simply to the mechanical support of adjacent textures and to the preservation of form; or it is present as a means of facilitating motion. The capillaries represent merely so many instruments for the conveyance of nutrient materials to the textures, which themselves select, assimilate, and absorb.

Modified in one way these elements are presented to us in the form of mucous membrane: modified in another way, with additions subservient to protection, motion, &c., they occur as integument or skin.

It is of the essential elements of the mucous tissue, and of certain appendages to these as they occur in the skin of the *Muræna*, that we are at present to speak. The appendages alluded to are certain layers of fibrous tissue, which from their form and arrangement seem to be in some way subservient to motion.

Instead of considering the germinal membrane as a whole, it will render our remarks more intelligible to treat separately of its inflections in the form of glands; of its epithelium and its modifications; and lastly, of the layers of fibrous tissue on which the basement membrane is placed.

If the surface of a vertical section of the skin be examined with the naked eye, it will appear divisible into two pretty equal parts; — an outer one, dark, dense, firm and semitransparent, and an inner one, yellowish, loose, oily and opaque. The former part consists of the epithelium, the germinal membrane, the pigment, the glands, and the fibrous tissue, which collectively constitute the skin proper; the latter of a very loose filamentous tissue, the interstices of which are filled with fat-globules. The loose tissue just mentioned forms the medium of connexion between the skin proper and the dense white fascia covering the muscles.

Epithelium.

The free surface of the skin is covered by several layers of epithelial cells. Although the form, and even the constitution of these cells varies according to their position on the skin, there are certain fixed characters common to the whole, — characters of which the different forms are simply modifications. With the exception of vibratile cilia, with which a few of the cells are furnished, the following is the general constitution of these bodies: — 1st, a transparent homogeneous

cell-wall lined on its internal surface by a layer of elementary molecules and granules: 2nd, an eccentric nucleus: and 3rd, more or less solid or fluid cell-contents.

In the majority of instances there is an additional layer of granular matter on the exterior or free surface of the cell-wall. These granules are rendered paler, but are not dissolved by acetic acid;* and their quantity appears to be increased on the addition of strong ammonia. The action of acetic acid upon these cells and their contents is much less strongly marked than is ordinarily the case in cells bearing the same structural relations. The cell-contents are either fluid or imperfectly solidified like gelatine: they are of an albuminous character, and have elementary granules imbedded in their interior. The nucleus is large, oval, slightly cupped, and marked by two dark circumferential rings. It is possessed of two coats,—an outer one, clear, structureless, and forming nearly two-thirds of the whole thickness of the nucleus, and an inner one investing an aggregation of dark, refractive, elementary granules. This body appeared to resist the action of ordinary re-agents: dilute sulphuric acid alone appeared to exert any effect upon it, and that, simply by rendering the central granules paler and less distinctly defined.

As illustrative of the principal modifications of these general characters in respect to both the constitution and form of the cells, I subjoin examinations of the mucus scraped from three different parts of the body,—*from the exterior of the mouth, from the middle of the back, and from around the anal orifice.*

In the matters scraped from the exterior of the mouth there were found, in addition to fluid mucus and elementary granules, three different forms of epithelial cells: these were the ciliated, the tessellated, and the caudate.

The ciliated epithelial cells were from three to five times the diameter of the human blood-disk, irregularly spherical, and analogous in constitution to the same bodies as observed in all the lower classes of the animal kingdom. Each cell was truncated, so as to form an abrupt extremity, which retained its form by means of a ring of elastic fibrous tissue to which the hollow pyramidal cilia were attached.

The tessellated epithelium occurred in the form of patches, the individual cells composing which were small — about $\frac{1}{1000}$ of an inch

* The cell-membrane strongly resisted the action of acetic acid: I could never dissolve it entirely by the use of this re-agent.

in diameter—thin, and derived evidently from the cutaneous follicles or glands.

The caudate-shaped epithelial cells were large, delicate, and nucleated. Their greatest breadth might be five, and their length eleven times the diameter of the human blood-disk. The one extremity was full, rounded, bulging, and contained the nucleus;—the other was narrow, and terminated in a filiform point.

The mucus taken from the middle part of the back exhibited the following cellular forms: 1st, the spherical: 2nd, the caudate: 3rd, the tessellated; to these forms of epithelial cells were added also, a few oil-globules. 1st, the spherical forms of epithelial cells. These varied in size from three to nine times the diameter of the human blood-disk. The smallest cells were nucleated and pretty darkly granular; the larger were paler and more finely granular, whilst the circumferential ring appeared darker and more refractive. The largest cells, though they presented few — and these morphological — differences from the others in anatomical constitution, appeared to differ widely in chemical composition. They were pale, smooth, and delicate; the nucleus generally interior; and the granular constituents either entirely absent or imperceptibly fine. They resemble delicate vesicles filled with oil; and by the action of ether were rendered still paler and less distinct. The first merged into the form last described by a series of almost insensible gradations; and they evidently possessed a definite morphological relation to each other. Of that relation, however, I am not at present prepared to speak: I indicate merely my belief in its existence.

The caudate forms of cells here met with differed considerably from those observed in the neighbourhood of the mouth. They were not pointed at the one extremity; in the majority the cell-contents were of a gelatinous consistence; exosmosis could not be induced in them; and in not a few the nucleus had escaped, carrying with it a portion of the original cell-wall and leaving a distinct hollow in the substance of the parent cell.

The tessellated forms were analogous to those already mentioned as having been found in the neighbourhood of the mouth, and will be described at large when speaking of the cutaneous glands.

Mucus scraped from around the anal orifice, exhibited cellular forms similar to those just described; but in addition to these, there were observed also certain combinations of epithelium, which will be noticed under the head of glands. The integument about this part was soft and velvety; and conveyed to the touch an impression simi-

lar to, but somewhat rougher than that experienced on moving the fingers along the mucous lining of the ileum in man.

By microscopic examination, this was found to arise from the presence of numerous villous-looking bodies projecting from the free surface of the skin. These were about half the size, and somewhat of the shape, of the villi met with in the human intestine. They appeared as long saccular projections from the skin, filled with granular non-nucleated corpuscles. The outline of each was dark, sharp, and depended evidently on the presence of a distinct limitary membrane. I could detect no cellular forms on the outer or free surface of these bodies: they resembled in their general outline the villi of the choroid plexus, but there was no apparent cavity and no trace of vessels in their interior.

The limitary membrane of these bodies presented on its inner surface delicate hexagonal markings, analogous to those met with in the middle or basement membrane of the scales of the *Percidæ:* I was unable, however, to trace the structural relations of that membrane to the other tissues of the skin.

These bodies would seem to possess a definite, though as yet unexpressed, relation to the various maturely developed dermal appendages.

Glands.

These are formed by inflections of the primary or germinal membrane and its epithelium; and are situated in the textures of the skin, on the free surface of which they terminate by open mouths. Some of these openings are visible to the naked eye; others require the aid of the microscope for detection: the former are confined to the lateral line; the latter are of two kinds, — the one studded over the whole surface of the skin, — the other found only around the anal orifice. These openings are the orifices of follicles, or glands, — the first and last superficially, the second deeply seated in the structure of the skin.

The glands of the lateral line are continued onwards to the head, with the ossicles of which they communicate by branched and complicated diverticula. It is to these glands, as they are found along the lateral line of the body, that I shall confine my present observations. These vary from four to nine lines in length, the chief portion of which lies in a direction nearly parallel to the surface of the skin. The orifice is about half the diameter of the body of the follicle,

which immediately within the mouth is pretty equal in breadth throughout. They do not resemble in shape, therefore, nor as we shall afterwards see in structure, the flask-shaped glands of the skin of *Amphibia*.

The margins of the openings of these glands are thick, rounded, almost papilliform; and their cavities, in the recent state, filled with small epithelial cells in various stages of development. When the latter are removed, the interior of the gland is seen to be lined by a layer of small, flattened, nucleated corpuscles, which, by pressure, may be forced out into the field and broken into irregular patches. These corpuscles are not completely flattened; are more or less regularly hexagonal, granular, and furnished with a nucleus which is imbedded in a number of elementary granules. It is seen also that these corpuscles rest on, and are attached to, a very delicate, almost homogeneous membrane, which, on the addition of ammonia, becomes distinctly granular. Lining the cavity of the follicle this membrane may be traced towards the free surface of the skin, in which it becomes lost to view between the epithelial and pigmentary layers. This membrane is the analogue of the primary membrane of the mucous and serous tissues; it is the basement or germinal membrane of that modification of the former termed skin, and though it cannot be *distinctly* demonstrated in the interfollicular portions of the integument, no reasonable doubt can, in this case, be entertained of its continuity throughout. In the present case, the pigment of the skin appears to occupy a somewhat anomalous position. In the higher animals it is said to occur in the inferior or young layer of epithelium cells, and is situated externally, therefore, to the supposed seat of the germinal membrane. In the tribe of animals under consideration, it would seem to be the reverse; for although numerous pigmentary granules are found in the epithelial cells, by far the greatest part of the cutaneous pigment is placed *beneath* the germinal membrane, is granular, occurs in rounded or stellar masses, and is not situated in the interior of cells, though it may possibly have had a cellular origin. The deep surface of this germinal membrane of the follicles is surrounded by a thick layer of inelastic fibrous tissue, which gives support to and determines the form of the gland. This layer is composed of distinct fibres, which appear as if regularly woven into each other, and which at the mouth of the gland are lost in the fibrous extension lying beneath the germinal membrane, and containing in its meshes the granular pigment of the skin.

Glands of the general surface.

In addition to the openings seen along the lateral line and visible to the naked eye, the general surface, as before stated, is studded with other openings of a similar character, but so much smaller as to become visible only to the assisted sight. The diameter of these openings is about $\frac{1}{300}$ of an inch, and nearly uniform throughout. They are rounded or oval; have their margins sharply defined, slightly elevated above the surface and surrounded by thickly set granules of pigment. In a vertical section of the skin, examined by transmitted light, membranous tubes are seen to proceed onwards from these openings to the subcutaneous filamentous tissue in which they terminate. The physical properties of this latter tissue offer a striking contrast to those of the skin proper. The latter is hard and dense, and thin sections may readily be made to transmit the light: the former is loose, soft, oily, of a dead white colour when compressed, and under all circumstances transmits the light with difficulty. Demonstration of the mode of termination of these tubes, therefore, is attended with considerable difficulty; and even when effected, is more the result of chance than of any peculiarities in the means employed. Under favourable circumstances, however, the termination of these tubes may be very distinctly made out. It will then be seen that they end in little saccular dilatations, more or less contracted at different points, as if the cavity were subdivided into compartments by imperfectly developed membranous septa. These tubes and their saccular terminations were generally filled with small oil-globules, which, by manipulation of the glasses, might be made to appear at the mouths of the follicles on the free surface of the skin. It was almost impossible to determine the exact structure of the parietes of these follicles, on account of the great diffraction of light produced by the oily matter in their interior, from which they could not be freed. Two sorts of fibrous tissue appeared to enter into the composition of their walls, —the one external, loose, reticulated, and connected with the subcutaneous filamentous tissue, and the other an internal or fibrous, coat proper, composed of distinct translucent fibres, marked by the presence of atrophied nuclei, and resisting the action of acetic acid. The inner surface of this latter tunic was very glistening, and appeared marked in various ways by horizontal and cross lines. These markings, though in some parts regular, I could not safely refer to a cellular origin. The saccular terminations of these follicles were each

imbedded in a quantity of loose filamentous tissue, containing numerous fat-globules in its meshes.

Glands around the anal orifice.

The openings of these glands were rather larger than those just described, and equal in width to any part of the cavity. The shape of each gland indeed might be likened to a semicircle, the flat surface of which would represent its mouth. The margins of these glands were slightly elevated above the surface, and surrounded each by a single layer of flattened epithelium. In structure, they resembled the glands of the lateral line; but the lining epithelial cells were larger and more delicate, and the surrounding fibrous tissue more scanty and fine.

Fibrous tissue of the Skin proper.

If a horizontal section of the skin be examined on its deep surface, by means of a simple lens, numerous bundles of fibrous tissue will be seen crossing each other at nearly right angles, so as to leave more or less regular quadrilateral interspaces. The one series of these fibres is circular, the other longitudinal, and both are placed somewhat obliquely, the latter more decidedly so than the former. These bundles occur in alternate layers that commence and end with the circular, which are somewhat larger and thicker than the longitudinal. Each layer is distinct, as are also the individual bundles composing it.

Prepared vertical sections of the skin, magnified about two hundred times linear, are best adapted for developing the structure and relations of this tissue. Examined by transmitted light, a section of this kind exhibits from without inwards,—1st, the germinal membrane and its epithelium: 2nd, a layer of reticulated fibrous tissue, containing the granular pigment in its meshes: 3rd, from fourteen to eighteen rolls or bundles of fibrous tissue running nearly parallel to the surface of the skin, traversed vertically — that is, from the outer to the inner surface of the skin—by the wavy tubes of the follicles formerly described, and by certain arctuous bands about to be noticed.

These rolls or bundles of fibrous tissue run in a direction nearly parallel to each other; their average diameter is about the $\frac{1}{100}$th of an inch; in shape they are irregularly rounded, quadrilateral, or flattened; and the extreme sides of each are marked by two irregular dark

refractive lines. Two or more of these layers occur in a section; and although the bundles composing each layer are placed on a level plane, and pursue a similar direction, they do not lie in immediate contact. Each roll, indeed, is separated from its fellow by a parallel depression equal in breadth to its own diameter, and about half as deep. The bottom of each interspace is filled up by one of the bundles composing the subjacent layer, and by the ends of the longitudinal fibres. Each of these cells or bundles of fibrous tissue is smooth on its exterior, of a yellowish colour, oily, and composed, apparently, of numerous molecular fibres, imbedded in a transparent structureless stroma or matrix. These molecular fibres appear to possess a longitudinal arrangement; but by long maceration in water, or by the addition of weak ammonia, the separate bundles swell up, become pale and granular, and lose every appearance of being composed of longitudinal fibres. These changes are more rapidly and decidedly induced by the action of weak acetic acid. On the addition of this re-agent, the separate bundles almost instantly swell out to nearly double their original size, and become more regularly rounded, exceedingly pale and studded with granules. Simultaneously with the occurrence of these changes, a number of persistent nuclei make their appearance along the margins of each bundle. These are small, transparent, of a yellowish green colour, and oval or somewhat elongated in shape. In this condition, each bundle appears as a rounded, structureless mass, studded with innumerable black points. These points or granules are arranged in a transverse direction, and it is in that direction too that the bundles when in this state are generally cracked or fissured. When greatly diluted acid was employed, the appearance produced in the bundles was very peculiar. Each bundle seemed to be made up of a series of smaller bundles of molecular fibres, twisted in a spiral direction, and imbedded in, or connected to each other by a transparent, structureless matrix. This latter appearance was exceedingly common, and could be at any time induced by the careful reaction of acetic acid.

These bundles are retained in their position partly by a fine, filamentous tissue, which surrounds them in every direction, but principally by numerous arctuous bands which proceed onwards from the areolar tissue beneath the germinal membrane, pass round the innermost fibrous bundle, and become firmly connected with the arctuous bands of other layers. These bands are composed of elastic, fibrous tissue, and in their progress inwards give off subsidiary bands, which

pass between the individual bundles and become connected with other offsets from different parts.

In the foregoing observations, I have confined myself to the detail of mere facts, which on that account must appear more or less unconnected; and I have refrained, purposely, from considering the genesis, development, and morphological relations of the tissues therein described. When my observations have been extended, I shall take an early opportunity of promulgating my views of the physiological relations of these textures.

EXPLANATION OF PLATE XXIII.

Fig. 1. Fibres of the fibrous tissue of the true skin. The figure on the left hand shows the effect of acetic acid upon these fibres.

Fig. 2. Openings of cuticular glands.

Fig. 3. The mode of arrangement of the fibres in the true skin and the ducts of the glands.

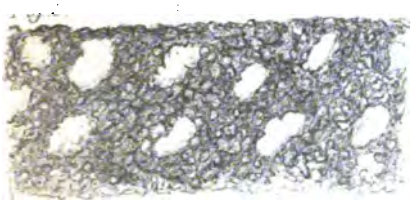
Fig. 4. Epithelial cells in the mucus from the middle part of the back.

Fig. 5. Epithelial cells from the exterior of the mouth.

Fig. 6. Epithelial cells from the neighbourhood of the anal orifice.

Fig 1

200 dia



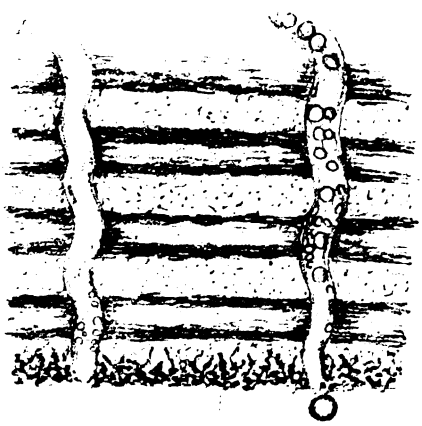


Fig 7

18 dia^s

Fig 4

200 dia^s

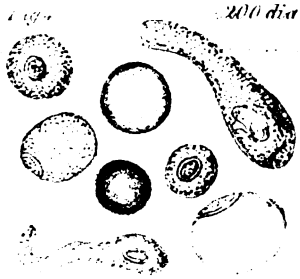
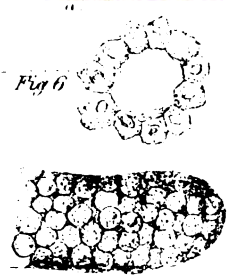


Fig 5

Fig 6



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XXVI.—*On the Value of the Microscope in the Determination of Minute Structures of a Doubtful Nature, as exemplified in the Identification of Human Skin attached many Centuries ago to the Doors of Churches.* By JOHN QUEKETT, Esq., Assistant-Conservator of the Museum of the Royal College of Surgeons of England.

(Read April 26, 1848).

THE vast number of highly interesting and valuable facts in natural history and in philosophical anatomy which are daily being revealed to us by the aid of the microscope, have quite established a new era in these sciences.

The links in the great chain of animated nature which heretofore may have appeared wide and discordant, have, by an intimate knowledge of structural anatomy been brought more closely together. Zoological classification, which in early times was based principally upon certain distinctions and peculiarities in external form, now begins to take a higher stand.

In one order of animals the nervous system, in another the digestive system, and in others the minute structure of the external or internal skeleton, form at the present time the best grounds for classification. Nature works with but few tools, but the material used, though often of one and the same substance chemically, is nevertheless moulded into an infinity of forms, and each form so perfectly characteristic of the genus, or sometimes even of the species of animals, that a microscopic examination only is required to identify them.

The force of this argument may be well exemplified by the structures termed Hair or Wool. In any two animals, of totally different genera, the hair when examined chemically may be in composition identical, but when submitted to the microscopic test, may be found so manifestly different that the unpractised eye can readily discriminate between them. No one, I am certain, is better aware of this than our worthy President, who has paid particular attention to the structure of hairs in different classes of animals, and no one is more likely

either to coincide in the opinions which will be here put forth, or to suggest some other explanation. Having premised thus much, I will now proceed to the immediate object of this communication. Early in the month of April, 1847, I was asked by Sir Benjamin Brodie, whether it were possible to determine if skin, which had for many years been exposed to the air, were human or not? I replied, I thought it would be possible if any hairs were present. He then spoke of a friend of his, Mr. Albert Way, whose name is so distinguished in the antiquarian world as one of our first archæologists, who was desirous of knowing whether certain specimens of skin, stated to have been taken from persons who had committed sacrilege, and which for centuries had been attached to the doors of churches, were unequivocally human. In reply to this, I stated again that if hairs were present, I had no doubt but the discrimination would be comparatively easy. Here the matter dropped, but on the 25th of May, 1847, I received the first of a series of five letters on this interesting subject, and as no language of mine could better explain the circumstances connected with it, I will take the liberty of reading such parts of these communications as will be necessary for our present purpose.

(No. 1.)

Wonham Manor, Reigate,
May 24, 1847.

Sir,

At the suggestion of my kind friend, Sir Benjamin Brodie, I am induced to trouble you with an inquiry, regarding which I shall feel much obliged if you will favour me with an opinion. A tradition exists in Worcester that a man having been caught in the act of committing robbery in the cathedral, was flayed, and his skin nailed upon the doors as a terror to the sacrilegious. The doors have been recently replaced by new ones, but they are still to be seen, and having written to a correspondent at Worcester to ascertain whether this strange tale were still remembered, he has sent me a portion of the skin, which is now only to be found under the iron hinges and clamps of the door. One small portion is enclosed, the inner side of which appears to have received the impression of the grain of the wood of which the door was formed. Would you have the kindness to tell me whether you can form an opinion from such a fragment as to the probability that it be *human* skin or not? The

inquiry may perhaps appear trivial, but as a similar tradition is to be found in two other places in England, and no reasonable cause can be suggested why the door of a church should be covered with skin, except from such motive as has been assigned, the question may not be wholly devoid of interest, were it only as regards the durability of human skin, exposed to the atmosphere in such manner.

I remain, Sir, yours faithfully,

ALBERT WAY.

On this specimen, which was about an inch long and half an inch wide, I succeeded in finding two hairs, and thus communicated to Mr. Way the result of their examination, "I have carefully investigated the portion of skin which you forwarded to me for my inspection, and beg to inform you that I am perfectly satisfied that it is human skin, taken from some part of the body of a light-haired person, where little hair grows. A section of the specimen, when examined with a power of a hundred diameters, shows readily that it is skin, and two hairs which grow on it I find to be human hairs, and to present the characters that hairs of light-haired people do. The hairs of the human subject differ greatly from those of any other mammalian animal, and the examination of a hair alone, without the skin, would have enabled me to form a conclusion. I may state that this is the second occasion in which from the hairs alone I have been enabled to pronounce an animal substance to be human."

In reply, I received this second communication.

(No. 2.)

Wonham, Reigate,
June, 4, 1847.

Dear Sir,

On my return home this evening I found your obliging and very satisfactory reply to my inquiry, and I hasten to return you my sincere thanks for your kind attention to my request. I must confess that I had almost feared you would have thought my curiosity of too trifling a nature to induce you to bestow on the little fragment I sent you such a scientific opinion as you have given me. I must remark that if Cuvier had not set us the example of eliciting valuable information from vestiges of the most trivial nature, we might not have attached so much importance to the evidence which may be

adduced from objects apparently insignificant. You have now excited my anxiety greatly to obtain specimens of the skin in the two places to which I alluded, — if tradition be of any value the duration of the animal covering must in these cases be very great, for the story is that the skin was taken from a Danish pirate, — this would take us back nearly nine hundred years. I hope to send you a sample. I can only state that Sir Harry Englefield accredited and communicated the tale to the Society of Antiquaries, a good many years since, and that when I was last in Essex, it was not forgotten. As regards Worcester, and the little portion which you have examined, you may rely on its being as described taken from a very ancient door now condemned and replaced by modern wood-work. There is another fragment of this skin in the collection formed by the late Dr. Prattinton, of Bewdley, bequeathed by him to the Society of Antiquaries, and this first drew my attention to it. If you think such a trifle worthy of a place in the invaluable Museum under your care, as connected with so strange a story, I hope to be successful in sending you a specimen of Dane's skin, older than the Conquest to place by it.

I remain, dear Sir, yours very truly,
ALBERT WAY.

On the 14th of July, I received a third communication, as follows.

(No. 3.)

Wonham, Reigate,
July 14, 1847.

Dear Sir,

I am enabled to forward to you a fragment, small indeed, but authentic, of the skin, traditionally supposed to have been that of a *Dane*, attached time out of mind to a door of the church of Hadstock, Essex, supposed to have been pillaged by him. You will very much oblige me if you can, according to your kind promise, aid me in verifying this singular tale, as you did so successfully in regard to the story at Worcester. Will you preserve the fragment for me, as the person who has sent it to me, has, I fancy, a value for the *relic*. I am chiefly curious as to the fact, which by your kind assistance, I hope, may be elucidated.

I remain, dear Sir, yours truly,
ALBERT WAY.

On this specimen I found three hairs without much difficulty, and wrote to Mr. Way as follows:—"I have been again fortunate in making out the specimen of skin you last sent me to be human; I found on it three hairs, which I have preserved. I should further state, that the skin was in all probability removed from the back of the Dane, and that he was a fair-haired person." At the end of the following month I was again addressed by Mr. Way to the following effect.

(No. 4.)

Wonham, Reigate,
Aug. 31, 1847.

My dear Sir,

I have again to trouble you in this curious inquiry regarding human skin attached to the doors of churches. I have been fortunate enough to obtain from the Incumbent of Copford, Essex, a portion of skin taken from the church door, and to which the like strange tradition had been assigned as in the two former cases, which you have so kindly taken the pains to elucidate for me in so satisfactory a manner. I am anxious to place these curious facts on record. Will you permit me to state them on the authority of the microscopic examination which you have had the kindness to give to these specimens? As soon as you may favour me with a verdict upon that now submitted for your kind consideration, I shall prepare a short statement for publication in our Quarterly Journal. If the portions of skin to which these strange traditions, long preserved, have by your friendly aid, been authenticated, should appear worthy to be deposited in the valuable collection under your charge at the College of Surgeons, I shall be much gratified in placing them at your disposal.

I remain, dear Sir, yours very truly,
ALBERT WAY.

On this portion of skin I found numerous hairs, which were both larger and darker than those from the other fragments, and to Mr. Way's communication I replied as follows:—"I am happy to tell you, that I have succeeded in making out the Copford specimen to be human, as well as the others: I have shown the hairs from

this, as well as from the others, to some friends who were sceptical, but they are now quite of my opinion."

(No. 5.)

Wonham, Reigate,
Sept. 24, 1847.

My dear Sir,

Pray accept my best thanks for your kindness in enabling me, so satisfactorily, to establish the strange traditions respecting these relics of humanity. My kind friend and neighbour, Sir Benjamin, has interested himself in the progress of the inquiry, and I hope to inform him, on his return to-morrow, of this fresh discovery. I hope that you will make such use of the facts as you may desire, and if you should wish for any further information, I shall be most happy to supply it. I think, however, that I stated the circumstances and tradition in each of the three cases, as I submitted them to your discriminating skill. Mr. Neville writes to me, that Mr. Towneley, the rector of Hadstock, had just obtained a scientific opinion in regard to the skin from that church, fully in accordance with your decision. I have enclosed the specimen from Hadstock—as you have been pleased to regard these relics as of sufficient interest to merit a place in the precious collection under your care. I wish the samples had been less diminutive; possibly you might have been able to give us an opinion as to the skin having been submitted to any preservative process. Regretting that they are so trifling in dimensions, I am gratified to be able to add to my sincere thanks any token both of my esteem for your kindness, and of my satisfaction at this alliance and cooperation betwixt Science and Archæology.

I remain, dear Sir, yours very truly,
ALBERT WAY.

For the information of those who may be called upon to undertake similar investigations, I will here state the mode of manipulating which was adopted in order to obtain the hairs from the three specimens of skin above described. The upper surface of each specimen

was carefully examined as an opaque object, with a magnifying power of forty diameters, and as soon as a hair was found it was seized with a pair of very fine-pointed forceps and torn out; the hair was then placed between glass, either with or without fluid, and viewed with a power of two hundred linear, which will be found quite sufficient to exhibit all the characters so fully known to microscopists. These are well shown in Pl. 24, figs. 1, 2, 3, by the accurate drawing of Mr. Leonard, and their identity will be established beyond a doubt, when figs. 1, 2, 3 are compared with that exhibited at fig. 4, which represents a small light-coloured recent hair taken from the arm.

It would, probably, be needless to dwell longer on the characteristics of human hair, as since the invention of the microscope no object has been more frequently examined, consequently its peculiarities of structure are universally understood. There is, however, one other point of great interest connected with human skin, that here deserves mention, and this is the comparatively small number of hairs with which certain parts of its surface are supplied; on reflection, we shall find that no mammalian animals, save those nearly allied to man himself, have any part of the body unprovided with hair, and had other than human skin been exposed to the same circumstances, some evidence of the abundance of the hairy covering would have been observed on microscopic investigation; but the present specimens, in the paucity of hairs found on them, fully bear out all the opinions that might, *à priori*, have been predicted of them. The specimen from Worcester, on its under surface, shows the markings of the grains of the wood, and the paint with which the door was covered; this would go far to prove that the skin was laid on when in a moist state, or soon after its removal from the body: but neither of the other specimens exhibits the same appearances.

Besides showing the great scientific value of the microscope, in bringing to light otherwise hidden truths, these specimens fully establish the wonderful power of skin and hair to withstand for centuries atmospheric influences, and serve to point out, that next to the bones, they are the most durable parts of the human frame.

EXPLANATION OF PLATE XXIV.

Fig. 1. A portion of the surface of the fragment of skin removed from the church-door of Hadstock, in Essex, exhibiting a hair projecting from it, magnified 320 diameters.

Fig. 2. The upper part of the same hair, magnified 500 diameters.

Fig. 3. A portion of the same hair, exhibiting the cellular structure of the interior, similarly magnified.

Fig. 4. A portion of a small light hair from the human arm, for the sake of comparison with the ancient specimens, magnified 500 diameters.

Fig. 1 Ancient Horn Mag. 320 diam.

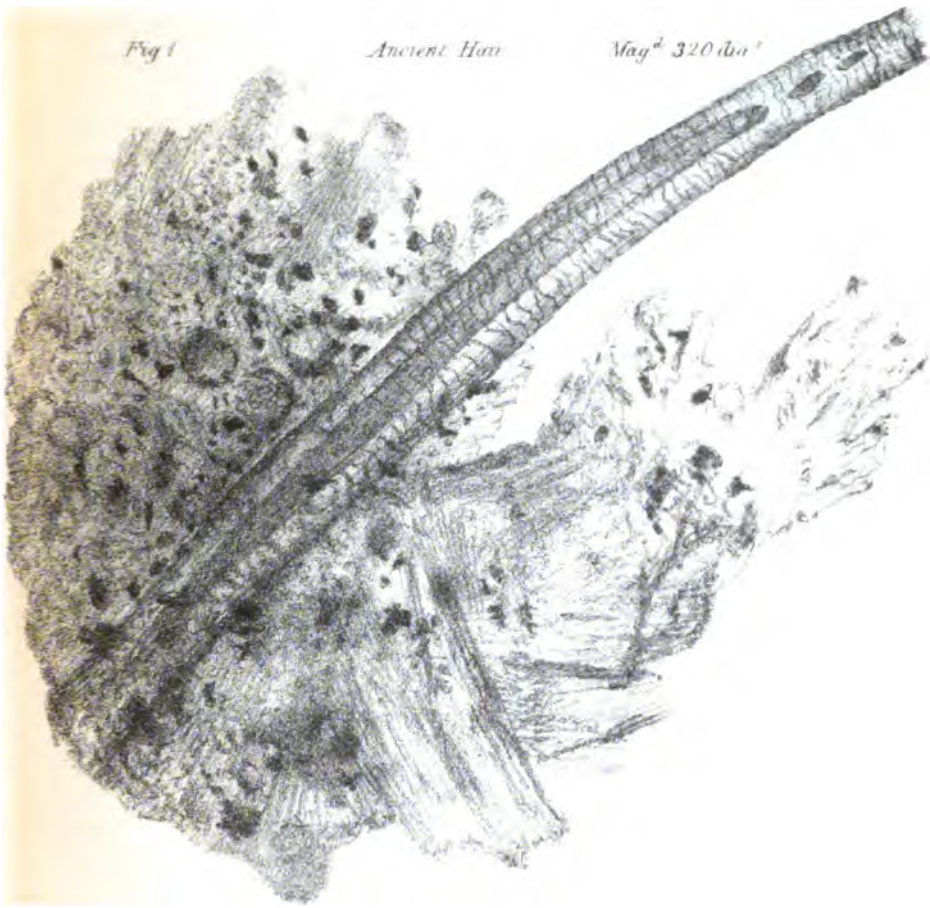

Fig. 2. Ancient Mag. 500 diam.

Fig. 3

Fig. 4 Living 500 diam.

S.W. Leonard del. et lith. E. Carter imp.

XXVII.—*On the Structure of the Shell and Soft Animal of Polystomella crispa; with some Remarks on the Zoological Position of the Foraminifera.* By W. C. Williamson, Esq., of Manchester.

(Read December 20, 1848).

The extensively diffused shells of the animals now designated *Foraminifera* have long attracted the attention of zoologists. The extraordinary abundance of recent species in sea-sands from every part of the globe, and the vast ancient deposits, especially of tertiary and cretaceous strata, presenting little more than accumulations of their fossil remains, caused them to be noticed by many observers at an early period: but from ignorance of their internal structure, and more especially of their soft parts, these singular creatures, as is well known, were handed over to the conchologists, who, up to the present time have admitted them into their publications, and still appear to claim them as a part of their own unquestioned domain.

The vague guesses of speculative writers soon assigned to the calcareous structures a soft animal having the form of a Cephalopod. De Montfort, though perplexed by the anomalous forms with which he had to deal, especially with his "genres d'autant plus remarquables, qu'ils ne présentent point de bouche ou d'ouverture proprement dite" ('Conchyliologie Systematique,' vol. i. p. 15) ventured boldly to assign to them an *internal* animal, indulging at the same time in a multitude of guesses as to the way in which it could keep up a communication with the surrounding medium. Notwithstanding the worthlessness of these speculations, De Montfort evidently made some accurate observations, and drew from them important inferences. Speaking of his *Polyxenes cribratus*, he says, "individuellement elle est entièrement criblée de pores, qui sont à jour. Organisation très digne de remarque, et qui sembleroit permettre le passage à autant de bras qui, comme ceux des polypes, saisiroient leur proie à l'instant où elle s'approcheroit: analogue qui nous conduiroit aux

animaux constructeurs des coralines. L'étude que nous en avons faite nous a prouvé que ces mollusques ètendent, dévelopent plusieurs bras, et que ces bras, malgré leur ténuité, sont armés des cupules, tout comme ceux des sèches, des poulpes et des calmars." ('Conchyliologie Systematique,' vol. 1. p. 139).

De Montford had evidently obtained a glimpse of the pseudopodia, but the "cupules" are imaginary. He distinctly denies their having been *internal* shells enclosed in the body of a mollusk, though he considered that they had the power of polishing their external surface, by means of an extensile mantle. A peculiar difficulty to which I shall afterwards have to allude, had probably attracted his attention.

M. D'Orbigny, as is well known, afterwards took the opposite view; and though not ignorant of many of their peculiarities, he considered them to be *internal* shells, surrounded by a cephalopodous mollusk.

M. Dujardin was probably the first to record the exact results of careful observations on the soft animals. He concluded that the calcareous shell contained little more than an animated slime, capable of protruding pseudopodia, but having little or no internal organisation.

The investigations of M. Ehrenberg have thrown new light upon the subject. The results, however, are too well known through the labours of Mr. Weaver, to require much in the way of recapitulation.*

* See Annals and Mag. Nat. Hist. 1841, p. 380.. Taylor's 'Scientific Memoirs,' vol. iii. p. 319, et seq. 1843. The latter memoir materially modifies some views promulgated by M. Ehrenberg in the former one, especially with reference to the relationship that existed between the shell and the animal. In the former paper, he concludes from an examination of his *Sorites orbiculus*, that these two tissues are identical. In the latter memoir, however, I find that he has published views on this point, agreeing with those which I had arrived at from examining some recent *Foraminifera* which he had not seen in a living state. For though he does not expressly refer to the results which he previously obtained from *Sorites orbiculus*, distinguishing between them and the conclusions to which he afterwards arrived, he speaks of the calcareous shell of the animalcule being "an external envelope like a snail's shell." (See Taylor's 'Scientific Memoirs', ut supra, p. 368). The same memoir, I find, also recognises the permanent oral (?) apertures in the calcareous shell, as the channels through which the *Naviculaceæ*, &c. have found their way into the interior of the chambers instead of through apertures in the skin, which became closed on the contraction of the latter, as according to his previous views. It was against these that my arguments were directed in two recent memoirs "On the Microscopic Organisms found in the Mud of the Levant;" (Memoirs of the Lit. and Phil. Soc. of Manchester, vol. 8); and "On the British Species of the genus Lagena," (Annals Nat. Hist. 1848).

As most naturalists are now aware, Ehrenberg considers the *Foraminifera* to be *Bryozoa*, closely allied to the polypiferous *Escharæ* and *Flustræ*. An improvement upon preceding classifications, but one that may perhaps even yet be amended.

No other authors that I am acquainted with, have published anything founded upon personal examination of the soft animals of recent *Foraminifera*, except what is contained in my two memoirs already referred to.

Whilst carrying on my investigations, the considerate kindness of my friend J. Gwynn Jeffreys, Esq., of Swansea, afforded me a valuable opportunity of examining the well-known British *Polystomella crispa* (*Nautilus crispus* auctorum), in a recent state. Cruising off Falmouth, Mr. Jeffreys observed a large *Laminaria* floating past him with a stone attached to its roots. This stone was covered with minute corallines. His quick and experienced eye soon perceived that amidst the branches of these small corallines, glistened multitudes of living microscopic atoms, and suspecting that it would prove a rich haul, he hurried the whole off to me, moistened with sea-water, and I had the delight of obtaining the animalcules in a fresh state. I found multitudes of *Polystomella crispa*, *Rosalina globularis*, *Lagena marginata*, and other forms, amongst the mass of residuum. Especially anxious to ascertain how far M. Ehrenberg's most interesting observations on his *Geoponus stella-borealis* (obviously a *Polystomella* of D'Orbigny) from the Cuxhaven sea, were applicable to our British species, I hastened to examine my treasures, and "after frequently-repeated observations and sections, fractions, sawings, and grindings," to use the expressive phraseology of Messrs. Jolie and Leymerie ("Observations on the Nummulites;" 'Comptes Rendus,' Oct. 25, 1847), who evidently understand the vast labour required to ascertain with certainty a few apparently simple points on these matters, I have succeeded in coming to several conclusions, showing that *Polystomella crispa* presents a soft animal of a type that differs from any that has yet been described.

Speaking of the above-named *Geoponus stella-borealis* (Ehr.), M. Ehrenberg says, "All the animalcules, even the most developed, of the two genera *Geoponus* and *Nonionina*, are like those of *Planulina* and *Textilaria*, without any prehensile apparatus at the head and without any circle of feelers around the mouth. Each body is surrounded by the hard shell, has an ordinary simple aperture, and the numerous adhering bodies of *Geoponus*, whose social form (polypidom) resembles surprisingly the individual animals of *Nonionina*, have just

as many visible simple apertures. On the other hand, the number of minute very extensile tentacula which at the same time effect the locomotion, and which project as it were from all parts of the sieve-like shell, evidently resemble the contractile fringes of the *Flustræ*, and of the marine Gasteropods." (Taylor's 'Scientific Memoirs,' vol. iii. p. 342, 1842). And again, "I never observed siliceous *Infusoria* in the intestines of *Geoponus*, but in these associated animals, the space is certainly closed for each individual, and consequently much more confined than in the single animals of *Nonionina*. After dissolving the shell with acid, where Dujardin found only a body remaining behind in the *Rotalia*, I was enabled, by a very slow process, to discover in both, also, a completely spiral, articulated, inner body, the single articulations of which were connected in *Nonionina* by *one*, in *Geoponus* by eighteen to twenty tubes (siphones) as connecting parts of as many individual animals, lying close to one another in each articulation." (Idem. p. 348).

M. D'Orbigny, speaking of the *Polystomella*, says, "Les *Polystomelles* se distinguent des tous les genres de *Nautiloidées* par ce caractère singulier, que les ouvertures du bord de la dernière loge, reparaissent en fossettes, plus ou moins allongées sur toutes les autres: les dernières seulement ouvertes, les autres toutes fermées. Il en resulte qu' extérieurement ce genre se distingue de suite par ce grand nombre de petits excavations transversales, qu' on remarque sur toutes les espèces; ('Voyage dans l'Amérique Meridionale,' tome 5me. p. 29); and in his description of the genus, he also adds, "Ouvertures nombreuses, éparsés en bordure, ou formant un triangle à la partie supérieure de la dernière loge, et se montrant encore ouvertes dans les fossettes suturales des dernières loges." (Idem.)

None of these descriptions apply either to the shell or to the soft animal of the British *Polystomella;* but before making any further general observations on this topic, I will state the results of my examination of our species.

This exquisite microscopic object has long been well known as a common organism amongst the sands of our shores, especially on the south and west coasts of the British islands. It is variable in its form, being sometimes broad and depressed, with the margin so thin as to be almost carinated; whilst in others it approaches to a more spherical form, the keel being thick and rounded. The periphery is sometimes entire; at others each of the smaller chambers, especially, has projecting from its anterior angle a small tubercular

spine, (fig. 1, *a*). In a still younger state, these are prolonged into stellate marginal rays (fig. 2, *a*).

The calcareous shell is divided into a great number of radiating compartments; the line of division being often marked externally by an elevated ridge. The interior of each chamber is convex posteriorly,* and concave anteriorly; on the exterior of each of these subdivisions, the shell is marked by a series of transverse folds or undulations (fig. 1, *b*, *c*), the "fossettes" of D'Orbigny, which are very distinct near the convex septum of the preceding cell, but usually disappear before reaching the concave margin of the subsequently formed chamber. The front wall of the last chamber (fig. 1, *d*) is nearly smooth; the central portion being usually flattened or truncate. Its outer margin exhibits no traces of large oral (?) orifices, communicating with the interior of the first chamber, but where the septum is in contact with the preceding convolution, there is an arched row of very small, and often wholly invisible apertures. These are usually so indistinct, that I long sought them in vain, and only from a few specimens obtained satisfactory evidence of their existence. As already remarked, the periphery of the young organism, when obtained from deep water, instead of from the water-worn sands of our beaches, is furnished with a circle of large, radiating, transparent, calcareous spines; those connected with the earliest formed cells being proportionally the longest (fig. 2, *a*). Whatever may be their use, they appear to become less necessary to the economy of the animal in its matured state, since in the larger and more recently formed segments, they first diminish in size, then degenerate into mere tubercles, and ultimately are wholly wanting (fig. 1, *a*). They are not, however, invariably present, even in the youngest individuals; some of the latter occurring not unfrequently with an entire periphery, which does not present even the slightest vestige of a spine. In this inconstancy they resemble many other forms of *Foraminifera*. The spine is to the single cell of a *Polystomella*, what the umbo is to a *Lagena* and an *Entosolenia*, or to the mucro of a *Triloculina* and a *Nodosaria*. It is an uncertain characteristic, which may be present or absent without affecting the integrity of the species. When by the growth of the organism these species become enclosed within the cells of the surrounding convolutions, they

* I have used the term "anterior," when referring to the convex *external* margin of each cell, and "posterior," when to the opposite or concave border.

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[illegible] n. In these the membrane was more

* I have [illegible] wn from a specimen mounted in Canada balsam, [illegible] tubercles shining through the shell.

are not absorbed, but remain projecting into the cavities of the subsequently formed chambers.

After making numerous sections of these shells, I found that what, externally, constituted the elevated folds or ridges in the transverse undulations of each segment (fig. 1, *c*, and 3, *a*), internally formed corresponding grooves (fig. 4, *a*), shallowed anteriorly, but deepening posteriorly, and before coming in contact with the septum in front of the antecedent cell (fig. 4, *c*), each receiving from that septum a small internal lamella (fig. 4, *b*), which for a short space converts them into perfect tubes (fig. 3, *c* and 4, *d*). To the left hand of the latter figure, the section has removed these inner plates and laid open the tubes. These do not penetrate the septum or form open channels of communication with the antecedent chamber; their extremities merely rest against it (fig. 4, *e*). On breaking into this adjoining chamber in thin and transparent specimens, and looking at the inner surface of its anterior septum, the circular outlines of these tubes may be seen through the hyaline diaphragm, which, however, closes them in.

On removing the whole of the front and lateral parietes of any one chamber, we find the positions of the extremities of these tubes represented on the front of the posterior calcareous septum, where we see an arched marginal series of circular depressions (fig. 5, *a*). These depressions do not appear to have been formed by the excavation or thinning of the septum; after a variety of examinations, I have satisfied myself that each septum separating two cells, consists of a double calcareous layer, — the soft inhabitant of each segment secreting its own share. The depressions appear to be formed by the absence of the *second* layer at the points opposite to the termination of the tubes, where the septum apparently consists only of a single layer, contributed by the antecedent segment of the animal.

Along the inner margin of each of these internal septa where it adjoins the next inner convolution, we find an arched row of apertures perforating the septum, in the position occupied by those already alluded to as being occasionally visible in the front of the first or outermost chamber (fig. 5, *b*). They are, however, much more distinct in the former than in the latter.

The microscopic texture of the shell is curious. It appears to be crowded with myriads of minute foramina, and in addition to this, it is evidently shagreened — covered over with small pointed tubercles (fig. 4, *f*), which, from the rounded form of their bases, may be easily mistaken for foramina, when the shell is mounted in Canada balsam,

and viewed by transmitted light. Where the tubes approach each septum retrally, we find that this tuberculated structure is very evident, particularly in the external depressions or "fossettes" of D'Orbigny, where the tubercles are very large, (fig. 3, *d* and 4, *f*, *g*)* forming an irregular row running parallel to the septum. Some authors appear to have mistaken these for a series of large foramina.

On removing the calcareous shell, by means of hydrochloric acid, I found that the soft animal body occupying the compartments was very curious (fig. 6 and 7). The anterior surface of each segment was convex (fig. 7, *a*), the posterior concave (fig. 7, *b*). From the two lateral margins of each segment there projected, retrally, a row of small obtuse processes, which, when *in situ*, obviously occupied the internal grooves and their terminating tubes (fig. 4, *a* and *d*). The inner arch of perforations (fig. 5, *b*) was occupied by a series of small connecting necks, which united the segments one to another (fig. 6, *b* and 7, *d*), and apparently formed exceedingly minute channels of communication between one chamber and another. Sometimes these tubes appeared to be constricted in the middle, as if half strangulated in passing through the narrow orifice in the calcareous septum.

This soft animal consisted of a very thin external membrane filled with a gelatinous matter; being analogous in this respect to what I had observed in *Rosalina* and other forms of *Foraminifera*. Dried specimens of *Polystomellæ* obtained from the British coast, have never afforded me any instances of these internal portions after being de-calcified,—a few minute shreds constituting all that was left. From my Falmouth examples, however, I readily obtained them, and found them to be translucent, and of a brownish colour. On drying the latter, previous to attempting to mount them in Canada balsam, I found that the evaporation of their contained fluid led to the total loss of all definite form and outline, leaving little more than a vague and unmeaning yellowish stain upon the glass. Scores of attempts only furnished me with one example which even approached success. This shows the extreme tenuity of the membrane and the fluid nature of its contents. After trying the same experiment upon a great number of individuals from near the Island of Tenedos and the Castles of Europe, in the Dardanelles, I was at last successful in obtaining a few beautiful specimens, from one of which the sketch (fig. 6) was taken. In these the membrane was more

* The latter figure, which is drawn from a specimen mounted in Canada balsam, shows the rounded bases of these tubercles shining through the shell.

dense than in our English forms, preserving, when dried, its external contour, as well as being beautifully transparent.

No trace of minute internal organization, such as a specially located intestinal canal, or ovaries, could be detected in any of these examples. The external membrane was studded in some of the dried specimens with a number of minute papillæ, of the nature of which I am as yet in doubt. Neither was I able, in any instance, to discover with certainty the presence of any foreign bodies in their interior, though some very minute siliceous organisms were placed in positions indicating the possibility of their occupying the interior of the segments.

The latter portions varied considerably in their form in different shells, especially when viewed in their antero-posterior aspects. In all they were more or less arrow-shaped; but were sometimes narrow and elongated, whilst in others they were more obtusely cuneiform. The lateral processes always projected retrally, but were never in any degree attached to the segment towards which their free extremities pointed.

The organism appears to commence its existence by forming one single spherical cell (fig. 6, *c*), as in most of the forms of *Foraminifera*, however varied may be their subsequent modifications. To this are gradually added a few more cells, which are linked together by single intervening necks (fig. 6, *d*), as is the case with the matured soft animals of *Rotalia*, *Rosalina*, and *Nonionina*. The cells of *Polystomella crispa*, however, rarely maintain this simple type beyond the first few cells. They soon become compressed and arrow-shaped; the connecting necks increase in number, and the marginal processes or cul-de-sacs begin to make their appearance. These latter appendages also become more numerous, until at length the matured segments exhibit the aspect presented by fig. 7.

These results necessarily lead us to some conclusions which differ materially from those arrived at by M. Ehrenberg, on the examination of his *Geoponus stella-borealis*. In the first place, he conceived that each chamber of the calcareous shell contained single segments of a number of distinct animals, packed closely one upon another; the continuations of which were to be found prolonged through the other chambers,—the different segments of each animal being connected together by single necks, as in that of a *Nonionina*, with which he distinctly compares each individual soft organism; of these he imagined he found many in one shell of his *Geoponus*, which he regarded as a kind of compound polypidom; and in the description of his figures, Pl. 5, *d*, *e*, *f*, and *g* (Taylor's 'Scientific Memoirs,' vol.

iii. 1843), he distinctly identifies each process of the soft animal, and what he regards as the corresponding tube or oral (?) aperture in the shell, with one individual animal; each being separate from the numerous others which he conceives are laid side by side with it, throughout the several compartments.

In our species, the articulation of the soft animal contained in each chamber is one integral segment, to which other similar ones, occupying the remaining chambers, are conjoined, combining to constitute one perfect animal. These segments are connected together by *one* row of necks in the very young state, and by several in the outer and more developed portions.

M. Ehrenberg considers that in his *Geoponus*, the tubes constituting both the outer and inner arches (fig. 5) are of the same nature; and that they alike perforate the septa, dividing the chambers from one another, and that prolongations of the soft animal pass through all these, forming necks, which intimately link together the soft contents of adjoining compartments.

In *P. crispa*, on the other hand, we have *two* classes of tubes, differing in their structure, and most probably in their function also. The *outer* ones do *not* pass through the septa, but are separated from the soft contents of the antecedent chamber by the calcareous film which formed its anterior wall or boundary, previous to other chambers being built up against it. Consequently the corresponding processes of the soft animal (fig. 6, *a* and 7, *c*) are not tubular connecting necks, or *open* channels of communication, but cul-de-sacs.

Supposing M. Ehrenberg's drawings and observations to have been accurately made, there is clearly a wide difference between his forms of *Polystomella*, and those of which *P. crispa* is a type; I have now examined many from various parts of the globe, and have found them all to assume the same general aspect and contour as that already described, the modifications merely affecting the relative size of the lateral processes, or the number of the connecting necks.

In sea-sand obtained from various beaches, ranging from Torquay to the Western Isles, as well as from the north-eastern corner of the Mediterranean, there is found in some degree of abundance a small but elegant *Polystomella*. The same species exists in considerable quantities in the ancient deposit of foraminiferous sand, extending under the fens of Norfolk and Cambridge. On mounting these in Canada balsam, according to the method adopted by M. Ehrenberg, I was at once struck with the close resemblance of this widely diffused species to his drawings of *Geoponus stella-borealis*. When

viewed by transmitted light, this resemblance was most complete. There were the same *apparent* siphons or lateral communications passing from the chamber, and for a little time I felt disposed in this instance to adopt his views. There were also, what he conceived to be the "bands of aggregated large apertures near the septa of the chambers (see his Plate 5, fig. *a*, *d*, Taylor's 'Scientific Memoirs,' vol. iii.), and the "numerous small apertures over the entire surface of the shell." No one dissimilar feature existed.

After a more elaborate examination, however, I ultimately became satisfied that the structure of these specimens was similar to that of *P. crispa*. When viewed as a transparent object, the lateral tubes appeared almost to project from the posterior or concave side of each septum and to be prolonged far into the cavity of the antecedent chamber. It became evident, however, that the *visible* line of the septum was merely that of the projecting central portion, which was very much in advance of the lateral sutures, where the walls of one chamber are attached to those of its antecedent; but since in the latter part, there are on each side two nearly horizontal and parallel layers, no distinct shadow is found; whilst in the projecting centre, where the septum assumes a direction vertical to the stage of the microscope, the light is intercepted, and a distinct outline rendered visible; the tubes, which, in this species are very much shorter than in *P. crispa*, appearing of course posterior to this outline, and seeming to be chiefly in and belonging to the cell behind it.

Specimens, however, frequently occur in which fractures extend across the first cell, reaching the true lateral junction with the second chamber, and exposing, without injuring, the anterior wall of the latter. These fractures traverse the dark line constituting the apparent septum, and reach the posterior extremity of the longest of the tubes, showing most distinctly that the latter terminate, as in *P. crispa*, with the posterior boundary of the cell or chamber to which they belong. The same species also satisfied me that what in M. Ehrenberg's specimens, he considered to be bands of larger foramina ranged along the lines of the sinuses, are in my forms, tubercular elevations on the exterior of the calcareous shell, such as I have already mentioned as existing in the corresponding portions of *P. crispa* (fig. 4, *g*).

Though I would speak with the greatest diffidence, not having seen M. Ehrenberg's specimens, I cannot help suspecting that his *Geoponus stella-borealis* is our widely-diffused little *Polystomella*,—and that the illustrious Prussian has, on this point, been inadvertently led into some errors by his favourite plan of mounting his objects in

Canada balsam, and looking *through* them instead of also looking *at* them; or, in other words, that he has trusted to observations made whilst viewing them as transparent rather than as opaque objects. I am well aware, from long experience, of the value of the former plan as an adjunct; it enables the observer to elicit many important points which would otherwise probably escape notice; but on the whole, the latter mode is even still more indispensable in investigating the contours of the *Foraminifera*.

M. Ehrenberg appears to me to have seen some of the internal connecting necks, and to have confounded these with the external marginal rows of processes, supposing them to have been identical in their nature and functions.

I am confirmed in these views by several points in his drawings, especially by his outlines of the front aspects of the *Geoponus* and of a *Nonionina* (see his Plate 5, fig. 2, *a*, *a*, and Plate 6, fig. 1, *d*). In the former he has represented a series of *square* marginal oral (?) apertures, where I suspect that none have existed; and in the latter the one corresponding aperture is omitted, whereas in *Nonionina* it is very large and conspicuous. These facts, combined with the vagueness of the outline, so different from the elaborate finish of the other drawings, leads me to suppose it possible that these two may not be actual representations, but theoretical sketches,—and that, were his specimens examined under good English achromatic instruments, they would be found to belong to the same type as those described in the preceding pages.

An important question now arises, viz., how are *Polystomellæ* supplied with nutriment?

I have already remarked that I found no definite traces of foreign bodies, such as the frustules of *Diatomaceæ*, &c., in the interior of the chambers; and the same negative fact was observed by M. Ehrenberg in his *Geoponus*. These substances are very common in *Rotalia Beccarii*, the various species of *Rosalinæ*, and other species which have large oral (?) apertures. Their absence from the *Polystomella* may be occasioned by the smallness and half-closed character of the same apertures in front of the first cell. These apertures may be sufficiently large to admit such food as these simple textures may require, and which may be conveyed from cell to cell by means of the narrow necks.

In addition to this, the fact of the calcareous shell being perforated by a multitude of minute foramina, shows that, as in M. Ehrenberg's species, and as is most probably the case in all the *Foraminifera*, the

P. crispa has protruded minute filamentous pseudopodia. May not these, in addition to their functions as organs of locomotion, also have the power of absorbing a supply of nutritive fluid? Dr. Carpenter states, "that in the *Actinia* fluid seems to enter and to be ejected, not only through the mouth, but through the tentacula also;" —('Principles of General and Comparative Physiology,' p. 117). If this be done by one of the more highly organized polypes, it is not improbable that, amongst the *Foraminifera*, the pseudopodia—which appear to take the place of the tentacula in the higher class of organisms—may also assume this function of absorption. The lower we descend in the animal scale, the more do we find the objects nourished by this process of exosmose and endosmose.

It is probable that the innermost convolutions may have the power of protruding pseudopodia, as well as the external ones; for though the calcareous portion of each of the latter completely embraces and encloses the former, the soft animal, as will be seen on referring to fig. 6, does not so completely cover in its own smaller whorls. But whilst in the decalcified animal we have a sort of umbilical cavity, in the calcareous shell this depression is filled up by a solid mass of carbonate of lime, *into which the decalcified animal does not extend*, but which nevertheless is apparently thickened by each additional convolution added on the growth of the shell; so that what in the one is the thinnest, in the other becomes actually the thickest part of the organism. But, as if to compensate for this, the surface of this central calcareous nucleus is pitted by small but deep depressions, which may be designed to facilitate the exit of pseudopodia from the innermost convolutions. This peculiar structure probably explains Ehrenberg's observations on his Cuxhaven specimens, when he found that the filaments were projected from the umbilical region *in bundles*, and he suggests that there may exist at that point distinct and larger apertures. It is however more probable, since no such large apertures are visible, that this aggregation of the pseudopodia into bundles, at the umbilical region, may have been occasioned by these depressions in the calcareous substance. Similar depressions exist in the little species which I suppose to be analogous to his *Geoponus stella-borealis*.

Another curious question arises out of this latter point. Since the external convolutions of the soft animal do not extend into this calcareous nucleus which covers up the central cells,—and yet each additional convolution contributes externally to its thickness,—from what part of the organism are these calcareous additions to the central por-

tion derived? We can comprehend each segment secreting, and surrounding itself with, a layer of calcareous matter; but how is the exterior of this nucleus reached? In the *Testacea* such a point might be accomplished by a voluntary extension of its mantle by the mollusk. In the present instance, I would suggest as possible, seeing that we have no such mantle capable of extension, that the central nucleus of lime may have been thickened, through the instrumentality of the pseudopodia which appear to penetrate it from the inner convolutions, and which, if this explanation prove to be correct, will thus possess an additional function to those already noticed. This, however, is a mere suggestion, arising from the difficulty of accounting for the appearance. The only other explanation which appears plausible, is, that the newly-forming segment, before enclosing itself in its calcareous cell, extends itself over the central nucleus, and then, gradually receding to what constitutes its permanent limits, leaves a calcareous layer behind it. The former idea however appears to me the most plausible one. De Montfort, in suggesting the existence of an extensile mantle capable of polishing the outer surface, had doubtless seen the difficulty of comprehending how the internal animal was to reach the exterior of the shell. The structure above described is most evident in the beautifully polished specimens which abound in the Mediterranean, and with which he was doubtless well acquainted. The true use of the rows of marginal processes (figs. 6, *a*, and 7, *c*) it is not easy to determine. The fact that each of their truncated extremities appears to come into direct contact with the foraminated wall bounding the preceding cell—the septum at that point seemingly consisting of a single calcareous layer, instead of a double one, as is the case with it elsewhere — rather indicates the probability of some indirect communication being kept up, through their means, between contiguous cells. This might be accomplished through the ordinary foramina already described, without necessitating any direct continuity or attachment of the one to the other; it is scarcely to be supposed that they have not some other nature than that of being mere sacculated appendages to the general digestive cavity; this, however, is a question for further investigation. I have seen nothing resembling either ova within the chambers, or the supposed petiolated egg-sacs of Ehrenberg attached to the exterior of *Polystomella crispa*. Ova of some kind must exist; and in the interior of some forms of *Rotalia* and *Rosalina* I occasionally find small bodies amazingly like spores, but I have found none in any species of *Polystomella*.

The new cells appear to be most probably added by gemmiparous

germination through the inner arch of small apertures: they are usually of a paler and more transparent aspect than those of older growth; but I have never yet seen any in process of formation. Sometimes the cells continue gradually to increase in size with symmetrical uniformity, when suddenly one of them is found to have been arrested in its development, not attaining to more than half its proper dimensions; and the new ones subsequently added are regulated in their increase of size, not by those which had previously attained to their full development, but by the one which has been so stunted,—from the contracted form of which the cells again continue to grow and increase in regular order; only being thrown back, as regards their size, by almost an entire convolution. This shows that the budding, if such it be, takes place from the part of the septum nearest the centre, and most probably through the small oral orifices,—the formation of the calcareous covering being the result of a process which goes on subsequently to the development of the soft tissues intended to constitute the future articulation.

It is scarcely necessary to add that the preceding details also show the inapplicability of the generic character of *Polystomella*, as given by M. D'Orbigny, to the subject of this memoir. It is only when one or more of the outermost chambers is broken away, exposing to view the front of one of the internal septa, that we find anything agreeing, even in appearance, with his description: it is certain that the "fossettes" have no sort of connexion with the true oral (?) orifices.

In an early portion of this memoir I alluded to the possibility of effecting some improvement as to the relative position in the scale of animal organisms which M. Ehrenberg thinks the *Foraminifera* ought to occupy. In the communication which he laid before the Berlin Academy in 1838, he came to the conclusion that they ought to be classed with the moss-corals (*Bryozoa ?*), and the 'Philosophical Magazine' for 1841 contains his new classification of the *Bryozoa*, in which they are included, being only separated from the highly-organized cilio-brachiate *Bowerbankiæ* and their allies by his order *Gymnocoræ*, containing the genera *Cristatella* and *Zoobotryon*. In his memoir read to the Academy in January, 1840, after he had made additional observations on his specimens from Cuxhaven, he says, "The other characters already communicated to the Academy in 1838, together with the position in the natural kingdom there given, are only confirmed and established by these subsequent observations."—(Taylor's 'Scientific Memoirs,' vol. iii. p. 344, 1842).

This classificiation is of course a great improvement upon those of

M. D'Orbigny and the conchologists, as it has entirely separated the *Foraminifera* from a group with which they had no manner of affinity, and brought them down to a much lower position in the zoological scale.

At the same time we must remember that the objects hitherto comprehended by naturalists in the group of *Bryozoa* are all possessed of a comparatively high organization. We find in nearly all of them a well-marked cilio-brachiate polype, having a limited number of localized tentacula, and a digestive cavity furnished with two orifices, serving as mouth and anus: the only exception to this regular form of the polype with which I am acquainted is that of the *Cristellaria*, in which the general contour is somewhat different, especially as regards the number and arrangement of its tentacula: but even these are ciliated, and the digestive cavity is furnished with two distinct orifices. Professor Rymer Jones observes, "that the existence of ciliæ upon the tentacula would seem to be characteristic of the *Bryozoa*, and is invariably accompanied, as far as our information extends at present, with a digestive apparatus of far more complex structure than what we have seen in the unciliated polypes; for in the class before us, beside the stomach, we find a distinct intestinal tube and anal outlet."—('General Outline of the Animal Kingdom,' by T. Rymer Jones, F.L.S., p. 108, 1841). Milne-Edwards also, whose researches amongst the *Bryozoa* have so justly rendered him an authority on this subject, briefly characterizes his *Polypes Bryozoaires* as "ayant un bouche et un anus distincts."—('Elémens de Zoologie.') Even could I be satisfied with the applicability, in any instance, of M. Ehrenberg's opinion, which assigns to some of the *Foraminifera* a localized intestinal canal, within the general sacculated cavity of the organism, still the great Prussian has not attempted to show the presence of either ciliated tentacula or of orifices which could have assigned to them the separate functions of mouth and anus; both of which classes of appendages must be demonstrated to exist ere the *Foraminifera* can be satisfactorily ranked with the true *Bryozoa*.

But even in the *Rotalinæ* and *Rosalinæ*, where the frequent presence of foreign bodies in their interior indicates the existence of a digestive apparatus, there appears to be no portion of the organism specially set apart for the performance of the functions of an intestinal canal; but the whole interior of the creature, including every articulation, appears to be one common digestive organ, as in the *Amœbæ* and many other *Infusoria*. In the *Polystomellæ* I have not hitherto been able positively to prove even thus much; for the only evidence of its

presence in other genera is obtained from the occurrence of foreign bodies within their articulations, and which have not been satisfactorily seen in the subject of this memoir. Hence the existence of the internal digestive cavity at all is rather admitted, from the general analogy which the *Polystomella* bears to other forms in which I have proved its presence. We find indeed little more than an animated slime, which, when dried, shrinks away—like some of the *Acephalæ*—to almost nothing; sometimes scarcely staining the glass upon which it is attempted to be preserved. Neither can this species be satisfactorily classed with any of the less complex forms of *Polypifera;* for even the "*Sertulariens*" of Milne-Edwards, the simplest groups of his "*Polypes Anthozoares,*" are described as "ayant un ouverture servant en même temps de bouche et d'anus:" and this is surrounded by a ring of tentacula. All these characters, which are also commonly recognized by other zoologists, are incompatible with the simple organization of the soft animal of the *Polystomella crispa.* It is perfectly true that in *Peneroplis,* and many other allied genera, we find numerous apertures, which, for want of a better name, are termed "oral," but these exhibit little affinity to the single central mouth and encircling tentacula of the true polypes. The orifices in the calcareous shell of the *Foraminifera* are probably more analogous to the minute tubular openings in some of the *Porifera*; and though often numerous in one individual, there is no possibility of dividing them into two groups, assigning to the one the special functions of a mouth, and to the other that of an excretory outlet.

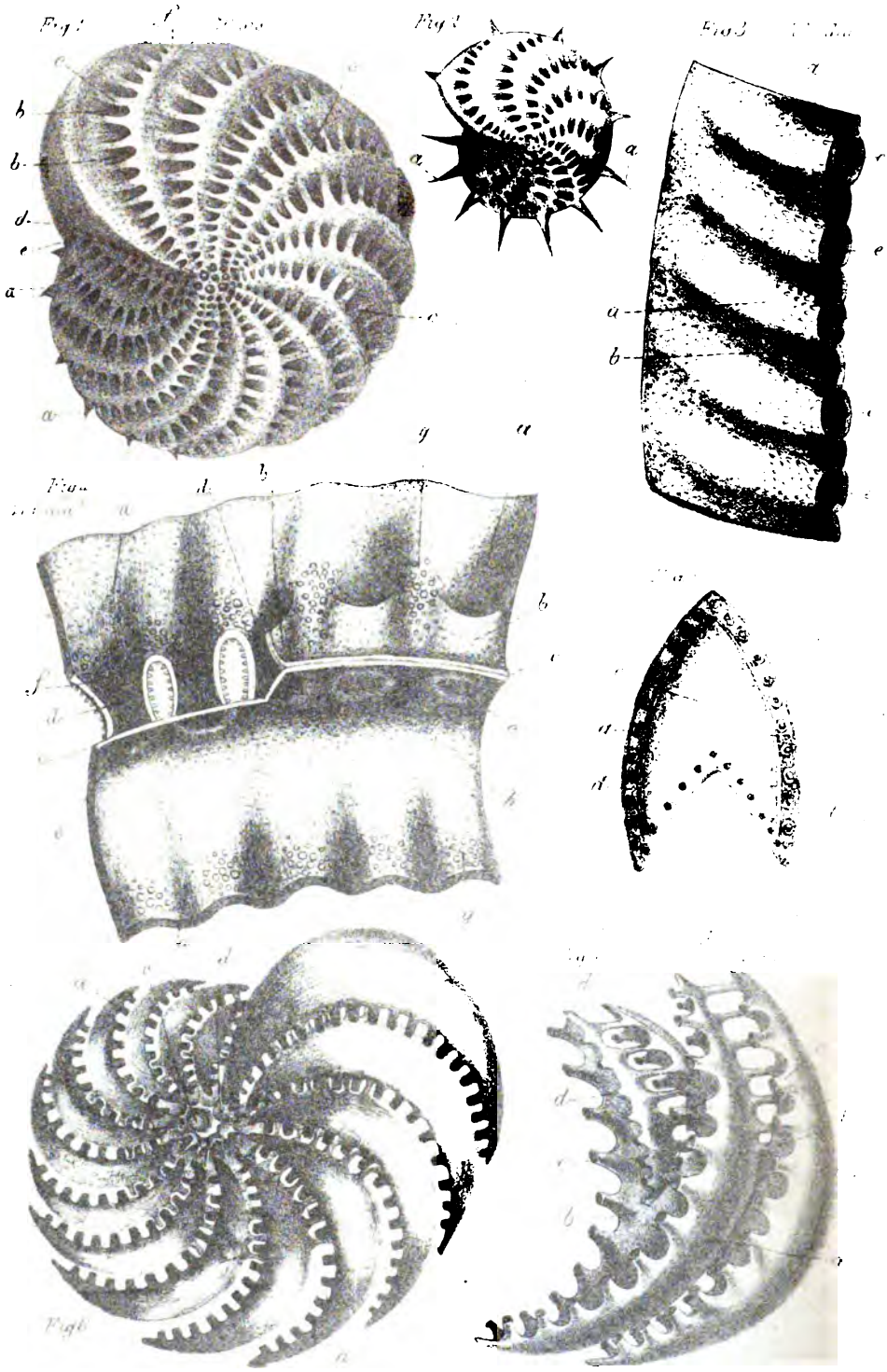
The rapid extension of physiological investigations shows, with increasing clearness, the impossibility of producing any satisfactory linear arrangement of organized structures; and in the objects under consideration this difficulty is especially manifest. In the low organization of their gelatinous tissues, we are reminded of the slimy forms of the *Porifera* on the one hand and the *Difflugiæ* on the other; only the horny skeleton and the triradiate calcareous spicula of the sponge are here exchanged for an external calcareous skeleton and an elastic lining membrane. But the existence of a decided internal digestive cavity, together with their well-defined retractile pseudopodia, give the *Foraminifera* a claim to a higher rank than is held by any known *Porifera.* The extension of the stomach, if such the gelatinous cavity may be called, throughout the organism, reminds us again of the *Amœbæ,* as well as the simpler species of Hydraform polypes, whilst many of the lower *Acephalæ* present an analogous watery gelatinous structure, numerous retractile filamentous organs of locomotion, and

a somewhat similar extension of the digestive apparatus into all the parts of the animal. Professor Rymer Jones has already pointed out how one connexion appears to be established between the *Polypifera* and the *Infusoria*, through the *Bowerbankiæ* on the one hand and the *Rotifera* on the other. May not the *Foraminifera* constitute another of these inosculating links, alike approaching the *Porifera* through the calcareous sponges, the *Infusoria* through the *Amœbæ*, the *Polypifera* through the *Cristallariæ* and the *Acephalæ*, whilst in any linear arrangement they might be placed immediately above the *Porifera*?

It may be necessary to vindicate my consistency by observing that my opinions on this subject have been modified since I published the preceding memoirs, already referred to, when I was more disposed to admire the classification of M. Ehrenberg, or rather was slow at believing that he could be in error. Further investigation, however, has led me to adopt the views which I now venture to propound; believing them to be more in accordance with the phenomena presented by the highly interesting objects to which they are applied. So little has hitherto been done in this department, which offers a wide field for observation on the part of those who live in a more favourable locality, that this memoir, as well as any other, must as yet be regarded only as an attempt to contribute something towards directing the inquiry into the right channel. It will but be after similar investigations are extensively multiplied, that general views can be permanently adopted with safety; since such peculiar forms of *Foraminifera* as *Orbiculina*, *Amphistegina*, and similar complex structures, only found in remote parts of the ocean, and which, consequently, have not yet been examined in the living state properly, if at all, cannot fail—when their soft structures are carefully investigated—to present highly interesting and novel results, and which might lead to the overthrow of all generalizations previously deduced from limited data.

POSTSCRIPT, *February*, 1849.

SINCE the preceding memoir was placed in the hands of the Secretary of the Microscopical Society, I have had the opportunity of perusing M. D'Orbigny's new work 'Sur les Foraminifères Fossiles du Bassin Tertiare de Vienne.' In the early pages of this volume he embodies the more recent views that have been promulgated respecting the nature of the *Foraminifera*, but without any acknowledgement of the labours of those whose discoveries have led to the abandonment of his original idea that the *Foraminifera* were cephalopodous animals. He has arrived at several conclusions, which are in accordance with my own results. He holds that they are *not aggregate* creatures: he recognizes the power of the pseudopodia to secrete the calcareous covering, — the universally rounded form of the primordial segment of the soft animal,—the inability of a segment once formed to increase its dimensions,—the absence of evidence as to the existence of a special intestinal canal, or organs of reproduction, and the power of the pseudopodia to absorb nourishment: all these being conclusions to which I have arrived in the preceding memoir, from independent evidence. As to their zoological position we differ considerably. He concludes that they ought to be arranged as an independent class, between the *Polypifera* and the *Echinodermata;* an opinion with which, from the reasons enumerated in the preceding pages, I cannot concur. His definition of the generic characters of *Polystomella*, is still the same as that which I have quoted in page 162, scarcely a letter being altered, and consequently, as inapplicable as its predecessors to the real types of the genus.



W. Wesmacott del.
W. L. Lowell lith.

E. Carter sc.

EXPLANATION OF PLATE XXVIII.

Fig. 1. Polystomella crispa; magnified 70 diameters, its ordinary size being about $\frac{1}{8}$ of an inch.

a. Small dorsal spines.

b. Externally depressed spaces, the "fossettes" of M. D'Orbigny.

c. Elevated folds, corresponding with internal grooves and their terminating tubes.

d. Front septum closing in the first chamber.

e. Row of oral (?) orifices, usually very indistinct, and often invisible.

f. Septa, separating the chambers.

Fig. 2. Young state of the same, magnified 70 diameters.

a. Translucent calcareous dorsal spines.

Fig. 3. Outer surface of part of the external wall of one chamber, exhibiting a section parallel with, and near to the posterior septum; magnified 400 diameters.

a. Elevated folds, corresponding with the internal grooves.

b. Depressed spaces or fossettes.

c. Tubular extremities of the internal grooves.

d. Minute calcareous tubercles, shagreening the exterior of the shell.

e. Internal plates, converting the grooves into tubes, posteriorly.

Fig. 4. Portion of the external walls of two cells, viewed from the interior; magnified 400 diameters.

a. Grooves corresponding to the elevated folds, fig. 1, *c* and 2 *a*, becoming converted into tubes at *d* by the addition of the internal lamina, *b*.

c. Part of the septum separating the cells.

e. Patulous extremities of the tubes, as seen in a transparent specimen, through the septum.

f. External tubercles, seen where the section has cut through the deep portions of the fossettes.

g. The bases of the larger tubercles in front of each septum, as seen through a transparent specimen.

h. Minute foramina crowding the calcareous shell.

Fig. 5. Front view of an *internal* septum, the lateral parietes of the subsequent cell being removed.

a. Outer arch of depressions (not perforations) marking the position of the extremities of the external tubes.

b. Inner arch of small oral (?) apertures, along the line of junction with the succeeding convolution, communicating between adjoining chambers, and transmitting the connecting necks of the soft animal.

Fig. 6. Soft animal of *Polystomella crispa*, as seen after the calcareous shell has been removed by the action of hydrochloric acid. The segments are drawn a little further apart than is natural, in order to show their structure.

a. Retral processes, occupying, when *in situ*, the grooves, and especially their terminating tubes.

b. Connecting necks, joining together the contiguous segments, and, when *in situ*, occupying the oral (?) apertures (fig. 5, *b*).

c. Primordial globular cell.

d. Young and partly spherical cells, connected together as in a matured *Rotalina* or *Nonionina*, by single necks.

Fig. 7. Oblique postero-lateral view of two segments (magnified 160 diameters) of the soft animal.

a. Anterior convex surface of the segment.

b. Posterior concave surface of the segment.

c. Lateral retral processes, corresponding to fig. 6, *a*.

d. Connecting necks, arising from the inner margin of each segment and attaching adjoining ones together.

Fig 5

Fig 1 d

Fig 4 c

Fig 1

Fig 2 a

Fig 2 b

Fig. 6.

Fig 1

Fig 3 b

Fig 3 a

EXPLANATION OF PLATE XXV.

Fig. 1. A magnified view of a whole small specimen of *Notamia bursaria*.

Fig. 2. *a*. Front view of a portion of a branch.

b. Back view of the same.

Fig. 3. Front view of the initial portion of the stem. *c*, *c''*. Initial cells. *d*, *d''*. Primary cells.

b. Back view of the same.

Fig. 4. Enlarged view of polype cell and tobacco-pipe process or cup.

a. Retractor muscles of polype.

b, *b*, *b*. Extrusor muscles?

c. Cup, shewing the muscles by which the beak is elevated and depressed, and indistinctly a hollow viscus contained in the cup.

d. Front view of the beak of the cup. The spot in the centre is the point of attachment of the depressor muscles.

Fig. 5. *a*, *b*. Diagrams to show how the branches are constituted of two series of cells, each of which has a cup or pair of cups at the bottom of the series.

Fig. 6. A diagram to explain the mode of derivation of each series from one or other of the primary cells.

EXPLANATION OF PLATE XXVI.

Fig. 1. A portion of *Anguinaria* associated with a *Campanularia*.

Fig. 2. Side view of the terminal portion of the polype cell of *Anguinaria*, showing the muscles by which the lower lip is depressed and elevated.

Fig. 3. Under side of the same portion.

Fig. 4. Upper side of ditto.

Figs. 5 & 6. Appearances frequently seen in *Anguinaria* as if the polype cell had been repaired.

Fig. 7. A highly magnified view of the lower portion of the polype cell of *Anguinaria*, showing the place of attachment and course of the retractor muscles, &c.

END OF VOL. II.

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Fig 2

Fig 8

Fig 3

Fig 4

Fig 6

Fig 1

Fig 7

41C
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